



*1st International Conference on
Project Economic Evaluation*



CONFERENCE --- PROCEEDINGS

ICOPEV'2011
28th and 29th April
Guimarães – Portugal

Message from the Programme Committee Chair

We would like to welcome you to the 1st **International Conference on Project Economic Evaluation**, in Guimarães, Portugal. The Conference is being organized by the School of Engineering of University of Minho in Guimarães on the 28 to 29 April 2011.

Our main goal is to join together in this event academics and practitioners from a variety of fields with interest on the issue of the economic evaluation of projects. We expect to provide a forum of debate for researchers and practitioners, contributing this way to support the sharing of experiences, to promote cross-knowledge and to strengthen the academic-industry relationship. This year's topic of the conference is **BAT in Manufacturing Industry**. Papers related to this theme or to the general scope of the conference were most welcome.

It is also an opportunity to visit Guimarães, a magnificent city of medieval origin known for being the cradle of the Portuguese nation. You may then admire the remarkably well preserved Historical Quarter of Guimarães classified by Unesco as World Heritage site since 2001, getting also in contact with the popular traditions and taste the famous gastronomy of the Minho region.

We are looking forward to meeting you again in the second conference on Project Economic Evaluation.

Madalena Araújo

Professor of the Department of Production and Systems

University of Minho

Scientific Committee

Madalena Araújo,
University of Minho, Department of Production and Systems, Portugal
(Scientific Committee Chair)

Teresa Amorim,
University of Minho, Department of Textile Engineering, Portugal

M. E. J. O'Kelly,
National University of Galway, Ireland

Richard Keegan,
Enterprise, Ireland

Lígia Pinto,
University of Minho, School of Economics and Management, Portugal

Isabel Soares,
Faculty of Economics of Porto, University of Porto, Portugal

Andrés Faíña,
Department of Economic Analysis, University of Coruña, Spain

Enrique Arez,
Escola Técnica Superior de Enxeñeiros Industriais, University of Vigo, Spain

António Paisana,
University of Minho, Department of Production and Systems, Portugal

Leonel Santos,
University of Minho, Department of Information Systems, Portugal

Organizing Committee

Madalena Araújo,

University of Minho, Department of Production and Systems, Portugal
(Organizing Committee Chair)

Teresa Amorim,

University of Minho, Department of Textile Engineering, Portugal

Paulo Afonso,

University of Minho, Department of Production and Systems, Portugal

Jorge Cunha,

University of Minho, Department of Production and Systems, Portugal

Paula Ferreira,

University of Minho, Department of Production and Systems, Portugal

Manuel Lopes Nunes,

University of Minho, Department of Production and Systems, Portugal

Fernando Romero,

University of Minho, Department of Production and Systems, Portugal

Anabela Tereso,

University of Minho, Department of Production and Systems, Portugal

Filipa Vieira,

University of Minho, Department of Production and Systems, Portugal

Conference Venue

Guimarães is located in northwestern Portugal, approximately 350km north of the capital, Lisbon, and about 50km from the second largest city, Oporto. Guimarães benefits from the proximity to the Francisco Sá Carneiro International Airport, located in Oporto and used by the most important airlines, including low cost airlines, for domestic, international and transcontinental flights. From Francisco Sá Carneiro International Airport you can easily reach Guimarães either by private car, train or bus.

Guimarães is a city with a glorious historical past, whose history is linked to the origins of Portuguese language and the founding of Portugal's national identity in the 12th century. The Historical Quarter of Guimarães constitutes a unique vestige of a particular type of city design. It is characterized by the morphology of its medieval urban fabric, which comprises a succession of squares of great formal value and environmental quality, and a particular type of construction that is diversified, but with great formal unity overall, which was fully erected using traditional building techniques called rodízio (castled) partition wall and fasquio (lathed) partition wall.

This unique site, which UNESCO classified on 13 December 2001, is the city's most reproductive and lasting investment.

For further information about Guimarães please visit
<http://www.guimaraesturismo.com>

The International Conference on Project Economic Evaluation will take place at Hotel de Guimarães, a four star hotel Installed in a building with a modern and appealing architecture, fully integrated into the city center of Guimarães.

Scope and Objectives

The project evaluation and selection is recognized as an interdisciplinary field requiring engineering, economic, social and financial expertise skills. Projects compete for scarce resources and choosing the best allocation of these resources is a complex and challenging task that decision makers face every day.

Methodologies and techniques must be defined and implemented, aiming to support the decision making process according to the goal of each organization. As society changes, the goals change too. It is now evident that complex decision making cannot be based only on financial criteria. From the private company point of view, aspects like the strategic dimension of projects, or its alignment with the company's strategy, the contribution to long term objectives or employees' wellbeing must not be overlooked. The same way, the economic perspective of the project underlines the need to properly consider and include in the analysis the social and environmental dimensions of the projects as decision variables.

The main goal of this Conference is to join together academics and professionals from a variety of fields with interest on the issue of the economic evaluation of projects. The Conference is expected to provide a forum of debate for researchers and professionals, aiming to support the sharing of experiences, promoting cross-knowledge and strengthening the academic-industry relationship.

Conference Topics

BAT- Best Available Techniques

Benchmarking

Cost/Benefit analysis

Externalities in manufacturing industry and services

Sustainable manufacturing

Sustainable new business models

Environmental decision making

Social and environmental impact assessment

Energy decision making

Evaluation of strategic projects

Technology-based projects

Digital Projects

Investment appraisal

Tools and methods for project evaluation

Multi-criteria for project evaluation

Decision support systems

Project risk analysis

Case studies

Keynote Speaker

Helder Rosendo

Vice General Manager of
CITEVE – Technological
Centre for the Textile &
Clothing Industries of Portugal,

with responsibilities as
Technology & Engineering
Manager and Communication
and Marketing Manager

STRATEGIC MARKETS FOR TEXTILE INNOVATIONS – GOING SMART & GREEN

Short CV

Vice General Manager of **CITEVE** – Technological Centre for the Textile & Clothing Industries of Portugal, since January 2009, with responsibilities as Technology & Engineering Manager and Communication and Marketing Manager; CITEVE's General Manager between 2005 – 2008.

Graduated in Textile Engineering, at **Beira Interior University**, Portugal, in 1994; Specialization in fibre processing technology, at the École Nationale Supérieure des Industries Textiles de Mulhouse, **Haute Alsace University**, France; Innovation and Industrial Property Management Executive Programme, at **WIPO**, Genève, (2007). Project manager of several R&D national and European projects; Team Manager on several industrial projects, within the field of technological and production consultancy.

CITEVE's delegate in several R&D working groups of **TEXTRANET** (European Textile Technology Transfer Network); Representative of the Portuguese Government on the European **High Level Group For The Textile & Clothing Sector**, namely on the Industrial Property Rights Working Group; Co-leader of the working group on Research & Technonological Development of the **EUROMED DIAOLGUE ON TEXTILES & CLOTHING**; CITEVE's Representative on the Thematic Expert Group (TEG) on *Novel Special Fibres and Fibre Composites for Innovative Textile Products* of the **European Platform on Textiles & Clothing**; Former President of **RECET** - The Portuguese Association of Technological Centres; Chairman of the Innovation on Textiles Panel from the **Europe Innova Initiative**; Member of the ADI (Portuguese Innovation Agency) experts panel for research projects evaluation

Keynote Speaker

Richard Keegan

BE, Ceng, MComm,
Phd FIEI Manager

Competitiveness Department,
encompassing Lean Business
and Benchmarking

Enterprise Ireland and European
Benchmarking Forum

BENCHMARKING FOR SUSTAINABILITY - AN ENVIRONMENTAL PERFORMANCE PERSPECTIVE

Short CV

Is a specialist in the areas of World Class Business and Benchmarking with Enterprise Ireland. He has focused on adapting these concepts for small and medium enterprises (SMEs). He has worked closely with a large number of companies, helping them introduce the concepts of world class manufacturing based on objective benchmarking. He has written several books on the topic and has lectured at Trinity College Dublin at post graduate and MBA levels, and as a guest lecturer at National University of Ireland – Galway, to both undergraduate and MBA levels. He acts as the European advisor to the World Class Activities of the EU-Japan Centre for Industrial Co-Operation. He lead the DG Enterprise Benchmarking Initiative, the European Benchmarking Forum and Network, focused on developing synergies and actions forward for benchmarking within the European Community as a means of developing the competitiveness of industry. He has trained as an engineer and has achieved Chartered Engineer status and a Master of Commerce degree on world class practices for SMEs. He has been awarded a Doctoral degree with National University of Ireland, Galway, for work based on the use of benchmarking and world class practices to improve the operational performance of SMEs using networks. He has recently been made a Fellow of the Institute of Engineers of Ireland. His latest book Applied Benchmarking for Competitiveness has been published in Ireland and India and has been published in a translated form in Portugal and Italy. Proceeds from the book are given to the Irish Cancer Society research Fund. He has worked previously for DAF Trucks, Nokia and Nestle.

Keynote Speaker

Nicola Raede

Consultant

Impact measurement –
Rigorous Impact Evaluation
and Results Based
Monitoring

METHODOLOGICAL REQUISITES FOR IMPACT EVALUATION FROM AN EX-ANTE PERSPECTIVE

Short CV

Impact measurement – Rigorous Impact Evaluation and Results Based Monitoring
Planning, execution and backstopping of evaluations in different contexts: e.g.
education, further education, vocational education, administration, development
cooperation (various sectors).

Focus on measuring impacts, impact evaluation design and execution.

Responsible for: research design, questionnaire design, data collection and analysis,
reporting.

Solid experience with surveys, online surveys, guided interviews, expert interviews,
group interviews, city walks, observation, data management and analysis with
SPSS, Excel etc.

Team Leader experience.

Implementation of results based M&E systems in several sectors, e.g. vocational
education.

Responsible for: M&E-design, further qualification of program staff, development
of data gathering instruments, assistance in data analysis.

Planning, execution and backstopping of further education training programs on
evaluation (FEEZ, GTZ, InWEnt, UdS, TrainEval, BMZ): Topics: evaluation in
research and practice, impact evaluation, organization of evaluation, indicator
development and assessment, quantitative and qualitative data gathering methods,
data management and analysis, reporting, results based monitoring.

Short Term assignments in following countries: China, Egypt, Ethiopia, Kenya,
Laos, Nepal, Philippines, Thailand, Uganda, USA, Vietnam, Zambia.

1st International Conference on Project Economic Evaluation
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Programme

Day 1: 28th April

8h30	Start registration
09h30-09h45	Opening Session
09h45-11h15	Technical Sessions
11h15-11h30	Coffee Break
11h30-13h00	Plenary Session
13h00-14h30	Lunch Break
14h30-16h00	Technical Sessions
16h00-16h30	Coffee Break
16h30-18h00	Technical Sessions
18h30-19h30	Social Programme
20h00	Gala Dinner

Day 2: 29th April

09h30-11h00	Technical Sessions
11h00-11h30	Coffee Break
11h30-13h00	Technical Sessions
13h00-14h30	Lunch Break
14h30-16h00	Technical Sessions
16h00	Closing Session

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ICOPEV'2011, Guimarães, Portugal

Day 1: 28th April

8h30	Start registration
09h30-09h45	Opening Session Prof. Vasco Teixeira Pró-Rector Prof. Paulo Pereira Dean of the School of Engineering Prof. Madalena Araújo Scientific Committee Chair Interdisciplinary Centre for Production Technology and Energy Prof. Fernando Nunes Ferreira Centre for Textile Science and Technology Prof. João Luís Marques Pereira Monteiro ALGORITMI Centre
9h45-11h15	Session A: Decision Support Systems Moderator: Madalena Araújo Micro enterprise individual program the factors determining to accession: an empirical study in the Valley of San Francisco, Brazil João Nascimento, Ana Santos, Adriana Silva, Juliana Reis and Francisco Ricardo Sustainable business models for Web 3.0 Leonor Gaudêncio, Fernando Almeida and José Oliveira Project portfolio selection and monitoring – A case study António Amaral and Madalena Araújo Technological extension program pilot project implemented in the capital goods sector in São Paulo - Brazil: promoting technological innovation Dorotéa Bueno, Fernando Romero and Filipa Vieira Technology evaluation and licensing: a literature review and an assessment of the Portuguese University technology transfer practices António Rocha and Fernando Romero
11h15-11h30	Coffee Break
11h30-13h00	Plenary Session Moderator: Eddie O'Kelly Strategic markets for textile innovations – going smart & green Hélder Rosendo Benchmarking for sustainability - an environmental performance perspective Richard Keegan Methodological requisites for impact evaluation from an ex-ante perspective Nicola Raede
13h00-14h30	Lunch Break

1st International Conference on Project Economic Evaluation
ICOPEV'2011, Guimarães, Portugal

14h30-16h00	Session B: Tools and Methods for Project Evaluation Moderator: André Luis da Silva Leite On the multi-mode, multi-skill resource constrained project scheduling problem – computational results Mónica A. Santos and Anabela Tereso Addressing sustainability: comprehensive frameworks for evaluating new product development Shantesh Hede, Paula Ferreira, Manuel Nunes and Luís Rocha Inter-firm cost management in high-tech product development projects in the plastics processing industry Carlos Nuno Barbosa, Paulo Afonso, Manuel Nunes and Marta Gomes Cost analysis for the economic evaluation of health care services Carla Duarte and Paulo Afonso An activity-based costing model for strategic decisions in transportation on demand projects Vítor Oliveira, Paulo Afonso and José Telhada		
	16h00-16h30	Coffee Break	
	16h30-18h00	Session C: Energy Decision Making Moderator: Isabel Soares Strategy for electricity supply of steel and mining sector firms Armindo Bredariol Junior, André Luis da Silva Leite and Nivalde Castro The role of energy planning on new hydropower plants investments Nivalde Castro, Guilherme Dantas and Raul Timponi Optimization models to support sustainable electricity planning decisions Sérgio Pereira, Paula Ferreira and Ismael Vaz Policy and legislation for a new energy paradigm: the case of the Portuguese legal framework for microgeneration José Gonçalves, Paula Ferreira and Paulo Afonso The electricity business: investment, risk and regulation Isabel Soares, Paula Ferreira and Madalena Araújo	
		18h30-19h30	Social Programme
		20h00	Gala Dinner

Day 2: 29th April

09h30-11h00	Session D: Investment Appraisal Moderator: Luiz Ozorio Decision-making process in investment projects Nuno Moutinho Project financing and verticalization in infrastructure project evaluation. A case study of Abengoa Luiz Ozorio, Roberto Brandão and Nivalde Castro Real options theory in comparison to other project evaluation techniques Bartolomeu Fernandes, Jorge Cunha and Paula Ferreira Evidence on the investment-cash flow sensitivity for a panel of Portuguese manufacturing firms Jorge Cunha and António Paisana Which project characteristics are important? What are the project success factors? Nuno Moutinho and Helena Mouta
11h00-11h30	Coffee Break
11h30-13h00	Session E: Cost / Benefit Analysis Moderator: Lúcia Pinto The cost / benefit analysis in the scope of the neoclassical economics Humberto Rito Ribeiro, José Manuel Pereira and Edson Luiz Riccio The evaluation of biomass power projects Patrícia Carneiro and Paula Ferreira A cost-benefit analysis of an intelligence and demand-driven public transport system for elderly and disabled Vitor Oliveira, Paula Ferreira and José Telhada Development of a cost-benefit model for micro CHP systems Ana Ferreira, Luís Martins, Manuel Nunes and Senhorinha Teixeira Cost-benefit analysis in occupational health and safety Delfina Ramos, Paulo Afonso and Pedro Arezes
13h00-14h30	Lunch Break

1st International Conference on Project Economic Evaluation
ICOPEV'2011, Guimarães, Portugal

14h30-16h00	Session F: Social and Environmental Impact Assessment Moderator: Enrique Ares
	Social and environmental impact assessment - theoretical contributions Nuno Moutinho and Helena Mouta
	Economic evaluation of a demand responsive transport in rural area: a case study Ana Dias, José Telhada and Sameiro Carvalho
	On the social return of R+D projects and support programmes Olalla Barreiro, Paula Ferreira and Enrique Ares
	Using expert interviews to create electricity scenarios and to assess social impacts Fernando Ribeiro, Paula Ferreira and Madalena Araújo
	The need for a new sustainable economic model Humberto Ribeiro Social impact on project assessment: an integrated methodology for the assessment of investment projects in Research and Development (R&D) at a society level Ana Fernández, Jorge Cunha and Enrique Ares
16h00	Closing Session Prof. Madalena Araújo Scientific Committee Chair Interdisciplinary Centre for Production Technology and Energy

MICRO ENTERPRISE INDIVIDUAL PROGRAM THE FACTORS DETERMINING TO ACCESSION: AN EMPIRICAL STUDY IN THE VALLEY OF SAN FRANCISCO

João Nascimento,^{1*} Ana Santos,² Adriana Silva,³ Juliana Reis⁴ and Francisco Duarte⁵

¹Doutorando em Contabilidade, Universidade do Minho, Portugal

²Licenciatura em Contabilidade, Faculdade de Ciências Aplicadas e Sociais de Petrolina, Brazil

³Doutoranda em Contabilidade, Universidade do Minho, Portugal

⁴Licenciatura em Letras Língua Portuguesa, Universidade de Pernambuco, Brazil

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KEYWORDS

Individual Entrepreneur, informality, economic development

ABSTRACT

The present study aimed to investigate which of the benefits offered, shown to be relevant to its membership. To this end, in order to verify to reality in the Sao Francisco Valley, questionnaires were applied 5-point Likert to 231 hawkers in the cities of Petrolina - PE, Juazeiro - BA and Casa Nova - BA, which identified 68 program participants. In this sub-sample was performed the procedure of factor analysis in view the objective of this study. It was found that the 15 benefits provided by the program, five showed a statistically insignificant at 5%. Because they are not relevant for joining the program, generate unnecessary cost to the government. Thus, it becomes necessary to reapply the study in other regions and, if confirmed such scenario, exclude insignificant the benefits in view of the intrinsic cost of such subsidies.

THE NEED FOR A NEW SUSTAINABLE ECONOMIC MODEL

Humberto Rito Ribeiro

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KEYWORDS

Economic models, Business cycles, Sustainability

ABSTRACT

Following the subprime mortgage problems that started in the United States (US) in the second half of the 2000's, the world would suffer the first financial crash shockwave of the 21st century, when the quasi collapse of the banking system in the US, occurred in September 2008, threatened the entire global financial network. The seriousness of the financial crisis became clear as it swiftly contaminated the major developed economies. Quarterly GDP growth turned sharply negative, in many cases reaching a two-digit decrease; and every major macroeconomic indicator, such as

industrial production, household income, or exports, suffered significant decreases. Understandably, the astonished general public started to questioning the current economic model.

In this paper it is argued that Marx was wrong: the dialectic of the social classes' clashes will not result in capitalism failure. Instead, sustainable issues will force capitalism to reshape in order to prevent the collapse of the humanity, which can only afford to live in a single planet, from which depends totally. This is significant for the way business is conducted, as even sustainable businesses may turn unsustainable if the planet collapses, being probably this the most likely reason to believe that a new sustainable model may be critical for mankind.

SUSTAINABLE BUSINESS MODELS FOR WEB 3.0

Leonor Gaudêncio,^{1*} Fernando Almeida² and José Oliveira³

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² Faculty of Engineering, University of Porto, Portugal

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KEYWORDS

Business model, Web 3.0, Semantic web

ABSTRACT

The information revolution created by the Internet quickly transformed communications into a vital part of business and everyday life. Currently the pervasive Internet is still evolving and is poised to enter in a new stage of development that will make it more intelligent, aware, and accessible. The next stage of the web creates the potential for individuals and organizations to use information in ways that facilitate the interoperability of devices and networks. As a consequence, companies should begin anticipating this new digital era now and prepare their organizations to compete and profit from this emerging environment. This paper looks to the semantic web and Web 3.0 technologies as enablers for the creation of value and new emergent business models. It identifies the main sources of value offered by semantic web technologies and proposes eight business models that a company can follow to adopt a successful Web 3.0 business strategy. Additionally, these business models were analysed in a long-term perspective, attending to the technologic and business risks associated with each approach and the sustainability of the generated revenues.

PROJECT PORTFOLIO SELECTION AND MONITORING – A CASE STUDY

António Amaral* and Madalena Araújo

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KEYWORDS

Project Portfolio Selection; MCDM; Case Study

ABSTRACT

Despite all the differences on markets, cultural environment, and organisational objectives, some changes are modifying the way business occurs, turning competitive advantages difficult to accomplish. In a global marketplace scenario, changes are constant and with variable amplitude. Organisations need to be alert to all movements to counter-answer and re-align themselves with the new market conditions. The organisational urge for using and applying new tools, methods and techniques is tremendous. However, there is no consensus about the type of method or technique that automatically improves any organisation, despite their own problems or status, restrictions and competitive advantages, strengths and weaknesses. Nevertheless, project management tries to see the organisation as a whole, and systematically challenge the difficulties encountered with new re-thinking processes in order to increase the organisational performance.

So it is of great importance to develop a flexible and expandable decision support system, which considers several different criteria, methods and phases in the most suitable way for the PPM, involving the full participation of the decision-makers and providing the users with a quick feedback impact, in certain parameters, of the consequences of the changes produced.

TECHNOLOGICAL EXTENSION PROGRAM PILOT PROJECT IMPLEMENTED IN THE CAPITAL GOODS SECTOR IN SÃO PAULO - BRAZIL: PROMOTING TECHNOLOGICAL INNOVATION

Dorotéa Bueno,* Fernando Romero and Filipa Vieira

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KEYWORDS

Technological innovation, Technological extension, SMEs, capital goods sector, Brazil

ABSTRACT

Technological extension is recognized by the Organisation for Economic Co-operation and Development (2005, OECD) as fundamental for economic development, by promoting and stimulating further technological innovation, especially in small and medium-sized enterprises (SMEs). This paper is written using the methodological reference and systematization of information available in the bibliography from the OECD. Based on this reference, the Ministry of Science and Technology of Brazil started four pilot projects to be implemented in São Paulo, Paraná, Santa Catarina and Bahia. These projects had two main objectives of putting in practice the technological extension service and analyzing its impact on firms. This article presents the process of implementation of the pilot in São Paulo. In this project, fifty firms of the capital goods sector were investigated. The results were the following: many firms showed improvement in the management of the production flow, a more consistent planning, a better control of many phases in the activity of the firm and increases in productivity. Based on these results, it can be concluded that the pilot program's technological extension proved to be relevant to SMEs due to specific management actions focused on the real needs of each firm, combined with the technological support provided and the low financial investment made by firms.

TECHNOLOGY EVALUATION AND LICENSING: A LITERATURE REVIEW AND AN ASSESSMENT OF THE PORTUGUESE UNIVERSITIES TECHNOLOGY TRANSFER PRACTICES

António Rocha and Fernando Romero

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KEYWORDS

Technology evaluation and licensing, intellectual property rights, technology transfer, technology transfer units, universities

ABSTRACT

To improve the access to information about practices supporting the application of research results we looked at strategies and methods described on the literature review and in use by technology transfer units (TTUs) having in mind a set of questions underlying the processes of technology evaluation and licensing in universities. The research questions gave us the opportunity to understand the TTUs degree of selectivity in the protection of inventions, the factors at the origin of licensing agreements and its main obstacles, the main evaluation methods and payment modes and they also gave us the opportunity to know the universities at study structure of dividend distribution. Underneath the answer to this questions we affirmed that the development of complete and demonstrable turnkey solutions and products decreases the investment risk and makes the technology more attractive to potential licensees, and we concluded that only knowing the economic value of an invention can we fully exploit its full potential and can we carry out an appropriate technology valorization strategy.

ON THE MULTI-MODE, MULTI-SKILL RESOURCE CONSTRAINED PROJECT SCHEDULING PROBLEM – COMPUTATIONAL RESULTS

Mónica A. Santos* and Anabela P. Tereso

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KEYWORDS

RCPSP, Multi-mode, Beam search

ABSTRACT

This paper is concerned with an extension of the Resource-Constrained Project Scheduling Problem (RCPSP) which belongs to the class of the optimization scheduling problems with multi-level (or multi-mode) activities. We developed a practical tool, useful to represent multi-mode projects, and to find a solution for the problem on hand – select the best mode for each resource in each activity in order to minimize the total cost, considering the resource cost, a penalty for tardiness and a bonus for early completion. We implemented an adaptation of a filtered beam search (FBS) algorithm to this problem, using the C# programming language. A “filtered beam” search is a heuristic Branch and Bound (BaB) procedure that uses breadth first search but only the top “best” nodes are kept. We give some of the most important solution details and we report on further computational results, by testing the application for different problem sizes.

ADDRESSING SUSTAINABILITY: COMPREHENSIVE FRAMEWORKS FOR EVALUATING NEW PRODUCT DEVELOPMENT

Shantesh Hede,^{1*} Manuel Nunes,¹ Paula Ferreira¹ and Luis Alexandre Rocha²

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KEYWORDS

Sustainability, Systems Engineering, New Product Development

ABSTRACT

The development and commercialization of novel sophisticated products, exerts a significant burden on the environment, throughout its life-cycle. Moreover, the environmental impact also generates a significant impact onto the socio-economic dimensions. Therefore, it is imperative to include criteria for addressing socio-economic and environmental sustainability. Previously developed approaches for sustainability evaluation, were comprehensive, resource intensive and lacked simplicity. The proposed framework for Sustainable New Product Development, utilizes a Systems Engineering Approach based on multi-criteria analysis. The investigation also proposes two capital budgeting based methods for evaluation, namely NPV@ Sustainability and Profitability Index@Sustainability using Life Cycle Assessment. These evaluation methods express the financial cash flows in accordance with the impact associated with the sustainability criteria and the core project milestones of the product development endeavor. The evaluation methods, together with the product development framework, are applicable during key decision points of Stage 2 and 3, in the Stage-Gate Process of New Product Development.

INTER-FIRM COST MANAGEMENT IN HIGH-TECH PRODUCT DEVELOPMENT PROJECTS IN THE PLASTICS PROCESSING INDUSTRY

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KEYWORDS

New product development, Inter-organisational cost management, High-tech environments

ABSTRACT

Companies are compelled to develop new products that accomplish several objectives simultaneously. Furthermore, competition is forcing organizations to collaborate more with their business partners. To meet this wide set of objectives, companies are embracing new tools and techniques to support successful new product development (NPD) projects. Inter-organizational cost management (IOCM) has been used by organizations to achieve the collaborative

management of costs throughout projects of NPD. Effective cost management which cross organizational boundaries has the potential to improve the overall performance of the project.

This paper presents and discusses inter-firm cost management in high-tech NPD projects, particularly the use of nanomaterials and nanotechnologies in the plastics processing industry. Processors are being asked to add value, complete more operations, deliver around the world, develop products and engage in partnerships with customers. In many cases, the supplier is becoming so integrated with the client that the former (supplier) is becoming linked to the success of the client. One result of this new strategic focus could be the “evolution” of IOCM.

COST ANALYSIS FOR THE ECONOMIC EVALUATION OF HEALTH CARE SERVICES

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KEYWORDS

Health Care Services, Economic evaluation, Cost analysis

ABSTRACT

Health care costs have increased significantly over the past years, especially due to the accelerating development of new diagnosis and therapeutic technologies and therefore the increasingly life expectancy, which have reported the need to maximize the results through the application of allowable resources. In this context, the development of models for economic evaluation of health care services stands for the analysis of comparative alternatives, evaluated in both their costs and their benefits.

In this article we examine the different models of economic evaluation of health care programs/services (cost-minimization, cost-effectiveness, cost-utility and cost-benefit), considering also the analysis of the various types of costs incurred and the ways to measure them, regardless the fact that indirect costs represent, in health care organizations, a considerable amount in the total cost of health services.

We thereby present a study on the possible ways to apply the various models of economic evaluation, the advantages and disadvantages of those applications in a hospital situated in the north of Portugal.

AN ACTIVITY-BASED COSTING MODEL FOR STRATEGIC DECISIONS IN TRANSPORTATION ON DEMAND PROJECTS

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KEYWORDS

DRT, strategic ABCM, Flexible Transport.

ABSTRACT

Today there are many people who lack access to adequate means of transportation (people with reduced mobility, elderly, people in rural areas of low population density, etc.). In these cases the conventional solutions do not serve and tend to worsen due to increased costs of private transport and the reduction of conventional transmission lines at these sites. In this context, emerged alternative transportation models called "transportation on demand".

However, although there are some experiments, these new models are still not consolidated due to problems of technical and conomic. Beyond the technical aspects necessary to develop cost models suitable for designing a system with economic viability and to set prices and pricing policies that ensure the attractiveness of the service without compromising their economic viability (namely with recipe above cost). The complexity of this system and the relative weight of significant indirect costs justify the application of a costing system based on activities. In this article we present a cost analysis based on the strategic ABCM model to discuss the conditions of economic viability of a transport on demand system applied to the municipality of Terras de Bouro. These results are important to support strategic and operational decisions.

STRATEGY FOR ELECTRICITY SUPPLY OF STEEL AND MINING SECTOR FIRMS

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KEYWORDS

Energy demand, Strategy, Steel industry

ABSTRACT

The steel industry's production process is electro-intensive. So, electricity has a significant participation in the cost structure of firms in the industry. An adequate energy portfolio management constitutes an important strategy to ensure the competitiveness of steel. In short, the sector's firms need to have assurance of supply of electricity at the lowest cost possible.

Energy-intensive industries need to take decisions relating to investment in productive capacity of electric power, and which sources should be prioritized, and the establishment of energy contracts and the profile of these contracts. These choices must be guided in the core objective of ensuring the supply at the lowest possible cost. However, an environmentally sustainable production presents itself as a competitive edge.

In this sense, the aim of this study is to analyze the performance of three major groups - Gerdau, Usiminas and Vale - on energy strategies, in Brazil and abroad.

THE ROLE OF ENERGY PLANNING IN NEW HYDROPOWER INVESTMENTS

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KEYWORDS

Hydroelectricity, Energy planning, Investments

ABSTRACT

A sustainable economic development program requires an energy system capable of meeting demand efficiently, while minimizing environmental impact. Countries that follow this path must integrate their energy systems with social and environmental concerns. The challenge is to combine development and sustainability, keeping in mind that social and economic development are associated with higher levels of energy consumption and increasing demand for natural resources.

Considering the importance of hydroelectricity to sustainable development, this study maps the main obstacles to increasing the hydropower share of electricity generation that exist even in countries with huge remaining potential. These examples underline the idea that promoting sustained economic development requires government planning and coordination of the energy sector.

OPTIMIZATION MODELS TO SUPPORT SUSTAINABLE ELECTRICITY PLANNING DECISIONS

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KEYWORDS

Energy decision making, electricity generation

ABSTRACT

Over the last decades, models and concepts related to sustainable electricity planning decisions have been changed according to the society, energy policy objectives and concerns. New and clean energy technologies are emerging as major contributors for the achievement of a set of imposed goals, being the energy efficiency combined with renewable energy sources (RES) a key strategy for a sustainable future. Power planning based on optimization models plays an important role for, not only electricity industry decision making process, but also for all processes where complex decision must be made. Following the idea of sustainability combined with the emergence of RES, this study aims to present an on-going research project that involves the development of a set of mathematical models to be used on the electricity planning. Assuming a time period of 10 years and through scenario analysis, the expected impacts in terms of costs and CO₂ emissions were evaluated. The behaviour of system when coal and gas fuel price varies is observed. The results put evidence the significant wind power and hydro power impacts on the electricity sector performance and demonstrate importance of these technologies to achieve the European Union goals for the sector.

POLICY AND LEGISLATION FOR A NEW ENERGY PARADIGM: THE CASE OF THE PORTUGUESE LEGAL FRAMEWORK FOR MICROGENERATION

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KEYWORDS

Microgeneration, Feed in Tariff, Regulation

ABSTRACT

Following the European Union energy strategies and recommendations, national governments are encouraging microgeneration related investments. The national government plays an important role on the effective introduction of microgeneration technologies into the markets and daily life of citizens. In the National Plan for Action on Energy Efficiency (NPAEE), the extensive use of microgeneration technologies in a decentralized electricity system is presented as one possible system to meet the future objectives of the Portuguese government for the energy sector. Several incentives were created to promote the adoption of microgeneration technologies through policy measures such as subsidies on the electricity generated by microproducers, investment subsidies and by creating awareness/informing the public about microgeneration.

This paper presents the Portuguese electricity system and the role of policy and legislation for the development of microgeneration in Portugal. The legal framework is analyzed along with the incentives and tax benefits for different microgeneration technologies. The detailed analysis of the Portuguese legal framework is made in order to ascertain the main features that may induce the project success or failure and the role of the defined payment rates namely identifying the possible success factors of these laws and regulations.

DECISION-MAKING PROCESS IN INVESTMENT PROJECTS

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KEYWORDS

Real Investment Projects, Non-Financial Analysis, Decision-making

ABSTRACT

We present projects evaluation approaches in what decision should be based. We try to understand what we have to take into account in a project analysis, knowing that we have to consider much unmeasured aspects, like non non-financial areas. We verify how all aspects are used and analysed in the project appraisal. We also desire to understand if companies have adequate tools and methods to correctly analyse and to take decisions in a project evaluation.

In this study we identify several aspects that are able to influence investment projects evaluation and decision-making process. An investment is not a mere financial activity, but involves a diversity of behavioural factors, organizational and business perception, which should be properly adjusted to invest with success. Investment decision-making should

take into account non financial aspects, mainly, through some evaluation's format and method. As non financial aspects have an intangible nature, they are difficult to estimate, and cause a subjective analysis to project evaluators, it is important to develop an objective and tangible method that incorporates and quantify all non financial aspects together in project evaluation.

PROJECT FINANCING AND VERTICALIZATION IN INFRASTRUCTURE PROJECT EVALUATION: A CASE STUDY OF ABENGOA

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KEYWORDS

Project Evaluation, Financial Strategies, Project Financing

ABSTRACT

The gradual transfer to private companies of public utility and infrastructure services has fundamentally changed the business environment for heavy engineering companies. This new competitive state of affairs has led these companies to assemble large investments in infrastructure assets. One that has adopted this new strategy is Abengoa – Spanish a firm focused on power generation, transmission and water utilities. Abengoa has been growing fast for many years, winning (in auctions) long-term public infrastructure contracts. The necessary infrastructure assets are built by Abengoa's engineering companies and construction is financed through highly leveraged financing structures, that include intensive use of Project Financing. Abengoa's case is particularly interesting because it allows us to understand how it is possible to build a highly leveraged capital structure, without compromising access to capital markets or hindering further investments in fixed assets. Abengoa's project evaluation model is also noteworthy as it combines in a single discounted cash flow both infrastructure project's cash flow and the gains obtained through vertical integration. This financial model also measures the impact of various types of debt, both at project level and at the corporate level.

REAL OPTIONS THEORY IN COMPARISON TO OTHER PROJECT EVALUATION TECHNIQUES

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KEYWORDS

Real Options, Discounted Cash Flow Techniques, Project Evaluation

ABSTRACT

Wrong investment decisions today can lead to situations in the future that will be unsustainable and lead eventually to the bankruptcy of enterprises. Therefore, good financial management combined with good capital investment decision-making are critical to survival and long-term success of the firms. Traditionally, the net present value (NPV) and discounted cash flow (DCF) methods are worldwide used to evaluate project investments. These techniques have been classified in two major groups: sophisticated and non-sophisticated. In the former group, techniques like the DCF methods (e.g. NPV and IRR) can be found. In the latter group, techniques like the Payback Period and the Accounting Rate of Return have been included. However given that, today investments are characterized by high risks and uncertainty, DCF methodologies are inadequate to deal with these issues. Some authors argue that only the techniques that can appropriately address the problem of uncertainty (like the Real Options theory) should be applied. In this paper, the major differences between DCF methods and Real Options (RO) theory will be analyzed. Using an example, the advantages of the RO theory, compared with other methods, such as the DCF methods, in the search of better decisions will be shown. This work is expected to contribute to an increase of application of the RO Theory, by showing this technique potential.

EVIDENCE ON THE INVESTMENT-CASH FLOW SENSITIVITY FOR A PANEL OF PORTUGUESE MANUFACTURING FIRMS

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KEYWORDS

Capital Investment, Financing constraints, Asymmetric information

ABSTRACT

In the last two decades, a renewed interest about the influence of financial factors on a firm's capital investment decision emerged. In fact, theoretical developments that occurred in the field of information economics, which emphasised the existence of information problems in financial markets, allowed to rationalise a close relationship between financial factors and investment expenses of firms.

This paper aims at contributing to the empirical literature on this subject, presenting the results of an empirical study undertaken for a panel of Portuguese manufacturing firms. The results obtained suggest that the impact of financial factors on investment decisions of firms is greater for those facing higher information problems in financial markets, such as: small, young and low retention firms.

WHICH PROJECT CHARACTERISTICS ARE IMPORTANT? WHAT ARE THE PROJECT SUCCESS FACTORS?

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KEYWORDS

Non-Financial issue; Project Success; Capital budgeting

ABSTRACT

The evaluation process of real investment projects must consider not only the traditional financial approach, but also non-financial aspects that can provide additional relevant information about projects. We investigate financial and non-financial areas most relevant in project appraisal, main critical success factors and areas of analysis that lead to the perception of project success, through nine hypotheses that are empirically tested. Companies are also segmented to verify their financial and non-financial practices, considering industries, type of project, size and duration of the project. The results show that non-financial factors affect the investment decision with larger importance than financial ones, specifically the strategic, technical and commercial areas. Perceived success of a project is related to the consideration of strategic, political and human resources aspects in its evaluation. There is a greater perception of success when companies attribute greater importance to financial and commercial aspects in project appraisal. The existence of many financial and strategic factors is associated with a greater perceived success of the project. We found that there is a greater perception of success in companies with larger projects, when the chairman of the board has higher tenure and when the project manager has a higher education degree and has variable reward.

THE COST/BENEFIT ANALYSIS IN THE SCOPE OF NEOCLASSICAL ECONOMICS

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KEYWORDS

Neo-Liberalism, Cost/Benefit analysis, Business competitiveness

ABSTRACT

The age of the globalization is inherently the age of the Neo-Liberalism, and it is therefore normal that Neoclassical theory dominates economics nowadays. On another strand, Cost/Benefit Analysis (CBA) is also critical for economics. A first main conceptualization of CBA was made by Alfred Marshall in the early 20th century. The CBA estimation measures the equivalent value of the benefits versus costs to the community of a wide range of projects, from highways to hospitals. "If the benefits to whomever they accrue [be] in excess of the estimated costs" then a given project will be worthwhile under CBA (US Congress, 1936, 1939).

Using a CBA approach, this paper examines whether the interventions of the monetary authorities in the financial sector were beneficial for the economy, and for business overall. Widely criticised, the authorities' "socialisation of the losses" resulted in higher budgetary deficits, forcing governments to hike taxes and therefore increasing costs for businesses, reducing competitiveness. Nevertheless, a non-intervention would result in a massive increase of business failures and in a major surge in unemployment, likely leading to a possible depression that would take years to tackle. Therefore, this paper contributes for the discussion of the desirable role of governmental and monetary authorities in the economic activity.

THE EVALUATION OF BIOMASS POWER PROJECTS

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KEYWORDS

Biomass, Energy Costs, Feed-in Tariff

ABSTRACT

Biomass is a renewable energy source attracting increasing attention. At the EU level in the last years a set of activities and programs were implemented in order to support and promote the use of this source of energy. This study addresses the issue of biomass costs for electricity production and the importance of incentives schemes such as feed-in tariff for the economic development of the sector. An economic evaluation of the electricity production from biomass is presented, based on a survey of both financial and social costs applied to the Portuguese case. Economic assessment was carried out by taking into account three types of biomass: energy crops (*miscanthus*), forestry residues and municipal solid waste. Four set of costs were considered and included: cost of capital, cost of maintenance and operation, fuel costs and external costs.

A COST-BENEFIT ANALYSIS OF AN INTELLIGENCE AND DEMAND-RESPONSIVE PUBLIC TRANSPORT SYSTEM FOR ELDERLY AND DISABLED

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KEYWORDS

Transport demand for people with reduced mobility, Externality, Cost-Benefit analysis

ABSTRACT

The current road public transport systems in Portugal are not suitable for most of its inhabitants, in particular those who suffer of reduced mobility. This inadequacy is mainly due to the lack of flexibility of the transport services provided and the poor level of physical accessibility (pathways and in-vehicle facilities). This study aims to estimate the effects of the implementation of public transportation systems designed to meet the specific market of public transport demand of people with reduced mobility (e.g. elderly and disable). The main factors affecting the system must be translated into a number of criteria and indicators to be included in the evaluation of potential transportation projects in this area. The study is based on a literature review and focuses on the analysis of externalities and decision making about public transport. From this review it is intended to develop an analysis of the externalities of the projects. It will be also

discussed the cost-benefit analysis for the project aimed at ensuring the sustainability of a transport demand for people with reduced mobility (TDPRM).

DEVELOPMENT OF A COST-BENEFIT MODEL FOR MICRO CHP SYSTEMS

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KEYWORDS

CHP system, Cost-benefit analysis.

ABSTRACT

In the last decade, new improvements on energy systems production have been conducted. The liberalization of the energy market, the search for alternative technologies using renewable energy sources, the sustainability of energy supply and the environmental issues are factors that emphasize the introduction of decentralized power generation systems.

The purpose of this work is to identify the variables that must be considered in developing an economic model to assess the viability of a new micro-cogeneration system for micro-scale applications. In the development of cost-benefit analysis, two types of variables should be considered: the internal variables that quantify and parameterize the operation and performance of the system; and external variables that evaluate the social and environmental impacts arising from the use of cogeneration technology.

The design of decentralized energy systems is usually carried out integrating technical and economic aspects. As a consequence, the assessment of CHP systems sustainability requires the analysis of operational cost-benefit analysis as well as the environmental and social impacts, which represent important external costs.

COST-BENEFIT ANALYSIS IN OCCUPATIONAL HEALTH AND SAFETY

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KEYWORDS

Cost-Benefit Analysis, Occupational Health and Safety, Delphi Methodology

ABSTRACT

The implementation of preventive and corrective measures within Occupational Health and Safety (OHS) lacks a proper systematic economic evaluation that allows to compare alternatives and to understand the impact of each of them.

Firstly, there should be a financial evaluation of the measures considering costs and income for the organization resulting from the implementation of identified measures. However, it is also important to perform an analysis of the impact of each measure in society, in other words, to measure the involved externalities. The measures taken by an organization to prevent risks usually have an indirect positive effect (positive externality) in society, while not taking any action, compared to the cost they represent for the organization, can have important negative effects to society (negative externality).

It follows that these different economic effects (for the organization and society) should be duly considered in decision making on occupational health and safety. This paper discusses the use of cost-benefit analysis related to Occupational Health and Safety. An exploratory qualitative study is proposed, considering the application of the Delphi methodology.

SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT - THEORETICAL CONTRIBUTIONS

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KEYWORDS

Project analysis; Evaluation; Social and environmental

ABSTRACT

When we have to make an investment decision, we have to consider social and environmental factors that can bring some doubts about the project. We analyse not only which social and environmental characteristics to assess, but also identify main risks and show how to mitigate them. In addition, we support the idea that both areas have to be analysed at the beginning of the project and that it has to be done at the time investors analyse other factors, in particular technical issues.

ECONOMIC EVALUATION OF A DEMAND RESPONSIVE TRANSPORT IN RURAL AREA

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KEYWORDS

Economic evaluation, Sustainability, Transport systems evaluation.

ABSTRACT

The provision of traditional public transport services in rural areas have shown to be very inefficient and ineffective. In fact, rural areas are typically characterized by low levels population density leading to complex demand patterns

(demand is low and spread over a large area) which leads to low levels of service of conventional transport services (low frequency, old vehicles, etc). Demand Responsive Transport projects have been seen as an interesting alternative solution already adopted in several countries. There are however some issues concerning demand responsive transport (DRT) costs and benefits that still have to be addressed. In this research work a global analysis about internal and external costs is proposed aiming to support decision makers investigating the impacts and measures related to the adoption of a flexible transportation system solution.

ON THE SOCIAL RETURN OF R&D PROJECTS AND SUPPORT PROGRAMMES

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KEYWORDS

Social Return, R&D Projects, Support Programmes

ABSTRACT

This work is a part of an ongoing research focusing on the social impact of R&D projects and support programmes from the perspectives of the public and private sectors. The research project is based on interviews conducted as part of a case study methodology involving a marine-sector private company and the Technological Center in Vigo. The results indicate that the criteria chosen as being the most important for the evaluation of social return of R&D were the number of jobs created at the company, the environmental impact and the working conditions. Also included in the analysis were the criteria used in the process of evaluating applications for funding. From the analysis it becomes notorious that social return is not a priority in this evaluation process, with assigned weights for the related criteria ranging between 0 and -22%. The only exception was the Transnational Program of cooperation Atlantic Space where the weights of the variable related to the social character of the project sum about 50 %. The mostly used criteria are the environmental impact, the incorporation of new PhD's and the presence of women investigator's in the project. Only in the Transnational Program of cooperation Atlantic Space include criteria like the transference of knowledge, diffusion of knowledge and platform growth.

USING EXPERT INTERVIEWS TO CREATE ELECTRICITY SCENARIOS AND TO ASSESS SOCIAL IMPACTS

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KEYWORDS

Scenario building, Social impact assessment, Expert interview

ABSTRACT

This paper focus on the assessment of the social dimension of electricity planning, resourcing to participative methodologies. A guide for interviewing power systems experts, covering a wide range of themes is presented. The guide focus on evolution of electricity consumption and supply according to each type of technology, driving forces among emerging technologies, energy policy, the relevance of sustainable development among institutions and markets and, finally, a first impression on the relevance of social impacts for candidate technologies. The main aim of the methodology is to gather discourses among experts and try to understand the connection between narratives and their consequences on the best scenarios under the social point of view. Therefore, the interview uses both quantitative and qualitative questions. The former are used for creating electricity generation scenarios within a 10 year range, while the latter aim at gathering each position's underlying explanations, which will be useful for cluster analysis in future work. The results presented in this paper refer to interviews which took place among the members of the working group of the project "Sustainable Electricity Power Planning".

SOCIAL IMPACT ON PROJECT ASSESSMENT: AN INTEGRATED METHODOLOGY FOR THE ASSESSMENT OF INVESTMENT PROJECTS IN RESEARCH AND DEVELOPMENT (R&D) AT A SOCIETY LEVEL

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KEYWORDS

R&D investment, social benefit, survey analysis

ABSTRACT

Nowadays, organisations increasingly need to adapt to the fast evolution of markets and societies in our globalised world in order to be competitive. Therefore, it is essential to take the right decisions when it comes to invest in R&D&i projects.

The present research focuses not only on the analysis of how R&D&i projects are assessed and selected but also on new proposals to improve them, with the aim of obtaining a suitable methodology which contributes to improve the competitive advantage and to integrate criteria of social nature both in organisations and in the Public Administration. The methodology which has been used in this research includes both interviews and analysis of the data obtained through them.

MICRO ENTERPRISE INDIVIDUAL PROGRAM THE FACTORS DETERMINING TO ACCESSION: AN EMPIRICAL STUDY IN THE VALLEY OF SAN FRANCISCO

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KEYWORDS

Individual Entrepreneur, informality, economic development.

ABSTRACT

The present study aimed to investigate which of the benefits offered, shown to be relevant to its membership. To this end, in order to verify to reality in the Sao Francisco Valley, questionnaires were applied 5-point Likert to 231 hawkers in the cities of Petrolina - PE, Juazeiro - BA and Casa Nova - BA, which identified 68 program participants. In this sub-sample was performed the procedure of factor analysis in view the objective of this study. It was found that the 15 benefits provided by the program, five showed a statistically insignificant at 5%. Because they are not relevant for joining the program, generate unnecessary cost to the government. Thus, it becomes necessary to reapply the study in other regions and, if confirmed such scenario, exclude insignificant the benefits in view of the intrinsic cost of such subsidies.

INTRODUCTION

Brazil, especially after the real plan and subsequent implementation of some structural reforms in recent years, emerged as a major global economic power. However, despite this reality, the country loses much of its competitiveness due to several structural problems, the problem of hiding from taxes.

The Government, aiming to find solutions, or at least minimize the current level of illegal in Brazilian economy, which comprises nearly 10 million illegal entrepreneurs (PADUAN, 2010:131), promoted the registration of these entrepreneurs, potential contributors, through complementary Law 128/2008, the Micro Individual Entrepreneur - MEI, enacted in July 2009.

Facing this scenario, it has become questionable to what extent the benefits offered to illegal workers are relevant for them to option of joining the program MEI? Facing this question, we performed a case study in the Sao Francisco valley, especially in the cities of Petrolina - PE with 290,693 inhabitants, considered the 6th largest city in Pernambuco, Juazeiro - BA with 194,096 inhabitants and Casa Nova, BA with 62,862 inhabitants, according to the IBGE 2010.

For processing, we chose to use a procedure of factor analysis, "that promotes the study group and the variables that explain the subject under study." The tool allows us to understand the composition of a set of variables on adherence to the phenomenon under discussion, the program MEI (FIELD, 2009).

Because it is a new theme, with a virtually non-existent search for theoretical framework, this study assumes greater significance because it contributes to debate on issues that promote the registration of illegal workers and serves as a reference for promoting further research on this theme.

The study is justified by the importance of identifying the predominant factors in adherence to the MEI program in view of its socioeconomic impact. The limitations of the study highlights the need to increase the sample (both for cities as for individuals), the possible antagonistic relationship between the individual micro entrepreneurs and beneficiaries of Bolsa Familia program, and finally, the deepening of factor analysis (constructs).

Besides this introduction, the study is organized in five sections. The first presents the key concepts that guided the research. The second one presents the methodological aspects used in the study and the third presents the analysis in the study sample.

The fourth and last part presents the final considerations that address the contributions coming from the studies and their limitations. To conclude, in the last session, are suggested some recommendations.

THEORETICAL REFERENCIAL

The Illegal workers in the Brazilian Economy

Underground workers are a major stigma of an unequal society and as such, should be minimized through government policies. Tanzi (2009:38) writes about the emergence of the underground:

As levels and tax rates increase, efforts by taxpayers intensify to avoid them and there is greater likelihood of tax avoidance through unofficial and unrecorded transactions.

Due to social pressure for access to basic services guaranteed by the Constitution, government spending has been substantially increased. This demand pushes a more efficient taxation, either by adding the number of contributors or by increase of tax rates.

Tanzi (2009) argues that the clandestine grows proportionally with the increase of taxes. As the operations conducted by illegal workers are not declared, the government does not tax and therefore does not hold all possible resources. This scenario ends by increasing the tax burden established thus creating a vicious cycle. Individuals, as a way to resolve the difficulties arising from this situation, aggravated by lack of jobs, joins the ranks of the underground industry of the Brazilian economy.

A study by the Getulio Vargas Foundation (FGV) and the Brazilian Institute for Ethical Competition (Etco), found that the underground economy moved in 2009 to R \$ 580 billion, or 18.4% of Gross Domestic Product (GDP), as shown Figure 1:

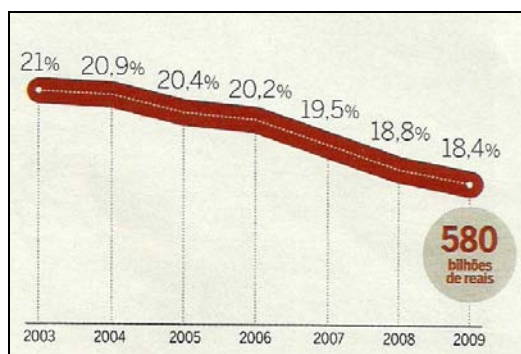


Figure 1 - Brazilian Underground Economy.
Source: Paduan, 2010: 129.

Referring to the amount of Micro and Small Entrepreneurs who qualify as illegal, the situation has shown a significant improvement in recent years, as can be seen in Figure 2:



Figure 2 - Universe of Small Entrepreneurs in the Brazilian economy.
Source: Paduan, 2010: 129.

Given the above, one can see that the world of small business owners who were operating undercover, with up to five employees, showed a significant improvement over the last 13 years, leaving from almost all, to a level of 83.7%.

The amount of small business taxpayers in the national economy, also showed increment in recent years, according to figure 3:

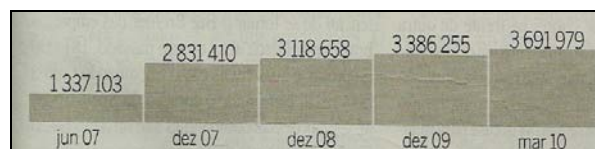


Figure 3 - Universe of Small Entrepreneurs in the Brazilian economy.
Source: Paduan, 2010: 129.

The business situation has changed substantially since the tax reform. Complementary Law 123/2006 created the National Simple, the taxation system that unifies federal, state and municipal governments, relieving the tax burden, and consequently encouraging small businesses to register. The government action has had great success, indicating good expectations for the coming years.

Individual Micro Entrepreneur (MEI)

The government, in order to fight illegal workers, has implemented a program aiming to reduce the underground economy, increasing collections and enabling access to those wishing to register. About setting the individual entrepreneur figure, Brazil (2010) states:

A person who works by himself and that legalizes as small business owner. To be an individual entrepreneur, you need to earn up to U.S. \$ 36,000.00 per year, not taking stakes in other companies as a partner or proprietor and have hired an employee who receives the minimum wage or minimum wage by occupational category. Individual Micro entrepreneur - MEI is regulated by Complementary Law 128/2008, with effect from 7.1.2009.

The law provides an improvement in the lives of those who are self-employed, providing rights through the legalization of their small business. It is then made available to millions of Brazilians the opportunity to get out of illegality and enjoy the aid, protection and other benefits being offered by the MEI.

In other words, the Law 128/2008 provides, to a casual employee, rising to the rank of small business, which includes a number of benefits for the employee and results in increased revenue for the state.

Due to the breadth of the universe, and especially the amount of illegal businesses and professions, it became necessary to restrict those who can join the program. Thus, for the formalization of individual micro entrepreneurial, the worker will have to frame their economic activity into one of the 439 occupations under the law.

When joining the program is provided, free of charge by the government electronic site dedicated to it, available at: <www.portaldopreendedor.gov.br>, or in person at accounting registered firms, who are responsible for the registration as also for the simplified first annual statement. The Brazilian System of Support for Micro and Small Enterprises (SEBRAE) is a partner of this program, providing guidance to the registration, as well offering free advice to beneficiaries.

The MEI program provides, to the new entrepreneurs, participation in the System of Fixed Monthly Payment in Securities Taxes covered by the National Simple (SIMEI), provided that the turnover is below the stipulated ceiling (R \$ 36,000.00 / year). As numerals I to VI of Article 13 of Complementary Law No. 123/2006, "the individual entrepreneur is not subject to the taxes as, IPI, CSLL, COFINS, PIS and employer Pension Contributions who have no employees (BRAZIL, 2010).

According to the law cited above, the Individual Micro Entrepreneur is exempt from the taxes that fall on the National Simple table by opting for SIMEI, providing economy of the amounts owed. About the tax aspects of the program, Brazil (2010) states:

Individual Micro entrepreneur (MEI) can opt for Payment of Tax System in Monthly Fixed Values, regardless of gross monthly income, allowing for savings in the taxes owed. Under the tax rate of 11% on a minimum wage for welfare, in fixed monthly amounts are R\$ 1.00 for GST activities of industry or commerce, and R\$ 5.00 for ISS services provide activities.

Note the wide appeal to simplification and economy for entrepreneurs. "Taxes must be collected until the 20th day of each month, using the collection document available for printing on the Generation Program Portal of the National Simple", which simplifies the contribution process enabling a saving on the taxes owed (BRAZIL, 2010).

METHODOLOGY

The study presents a quantitative approach and uses the inductive method of data collection, starting from a regional analysis of the relevance of each of the benefits provided by the MEI program, outlines a proposed explanation of the relevant factors of the option on joining the program at the macro level. "The steps of the method can be summarized as follows: observation, analysis, hypothesis development, experimental testing, model, and finally, generalization of results" (Kumar, 2005: 72).

The research is partially of descriptive nature, considering that "seeks to describe systems, techniques and procedures followed in practice" (MAJOR & Vieira, 2009: 144). Jung (2004:198) adds, "Aims to identify record and analyze the characteristics, factors or variables that relate to the phenomenon or process." However, it also has exploratory aspects, as "aims at the discovery, elucidation of the phenomena, or the explanation of those who were not accepted in spite of evident candidates" (Jung, 2004:197).

As for the procedures, we performed a case study aiming to explain / understand the motivations to join the program in the San Francisco Valley. Op cit (2004:204) argues about a procedure case study:

Through a case study can explain or describe a production system or technical system under private or collective entrepreneur, so this is considered an important tool for researchers that aims to understand how and why "things" work.

In order to obtain the data, the Brazilian Service to Support Micro and Small Enterprises, SEBRAE, from the cities of Juazeiro - BA and Petrolina - PE, has been consulted on the possible contribution to the study, providing the database of beneficiaries of the region to make possible the questionnaires. However, that body did not provided the necessary information, because of their confidential and sensitive information.

The accounting firms that provide advisory services, free of charge, to participants of the program were also consulted, however, also did not succeed in getting the contacts of the participants, bearing in mind the lack of such control by the accounting profession.

The accountants stated that due to legal restriction on joining the programs Individual Micro entrepreneur (MEI) and Bolsa Familia program, illegal entrepreneurs have been reluctant and, especially, abdicated to joining the program MEI over being excluded from the Bolsa Familia program. Thus, in view of this presented scenario, we tested the following hypothesis:

(H0:) There is an antagonistic relationship between the number of program choosers Individual Micro entrepreneur and social programs beneficiaries of the federal government.

We decided then to get the information directly into the search field, thus conforming with the procedure of administering the questionnaire to the street of the cities surveyed, regardless of whether they are opting for the program or not. Although possibly not obtain legitimate identification of the target, in order to effect the separation necessary to tabulate the data, was asked to identify the choosers of the program in the header of the questionnaire. Of the total 231 participants, about 30% fit as individual micro entrepreneur, according to table 1

Table 1: Number of participants opting for the program and MEI

Participants	Opting MEI	%
231	68	29,4

As the aim of the study was to verify the relevance of the relevant factors in adherence to the program, the data used was corresponding only to the 68 vendors who participated in the MEI program in the cities of Petrolina - PE, Juazeiro - BA and House - BA. The delimitation of the cities covered in the analysis, occurred mainly due to the unavailability of financial resources to cover the whole region, however, this aggravating factor did not affect the search results in order that the cities analyzed comprise 96% of the population in Vale do São Francisco (SERPRO / MDIC, 2010).

Questionnaires were administered during the months of August and September 2010, presenting an open question (descriptive analysis) and the other closed, using the Likert scale of five points, in order to facilitate the tabulation of data and consequently provide quantitative analysis of the phenomenon under study. In all phases of the study was used statistical software: Statistical Package for Social Sciences SPSS 17.0 ®.

We opted for the factor analysis for data treatment because it is a methodology widely used, especially by social researchers to measure constructs that cannot be quantified directly. Field (2009:553) states:

For example, students of directors (or psychologists) may be interested in measuring the exhaustion (burnout), that is when someone who has worked hard in one project (a book, for example) for a long period of time is suddenly deprived of motivation and inspiration and want to hit his head several times on the computer.

Still on the factor analysis, Hair (1998:193) quotes that one of his main tasks is to "construct a questionnaire to measure the underlying variables. In this study, the statistical technique of factor analysis was used to test the statistical significance of variables / benefits of the phenomenon, namely, adherence to the program of MEI.

DATA ANALYSIS

Preliminary Survey

There was a relationship between the number of people opting for MEI program in the face of receiving the Bolsa Familia program, in the North and Northeast, according to Table 2.

Table 2: opted subjects for the M.I. program X B.F. beneficiaries in the North / Northeast in 2009

STATE	SOCIAL BENEFITS	OPTING MI
BA	4.138.983	6.413
PE	2.648.109	858
CE	2.589.009	744
PB	1.222.857	627
RN	873.012	494
AL	1.039.467	414
MA	2.190.513	360
SE	537.006	165
PI	1.081.533	144
PA	1.590.774	750
AM	667.944	404
RO	276.612	328
TO	307.203	248
AC	165.747	198
RR	103.896	91
AP	118.158	154
Total	19.550.823	12.392

Source: SERPRO / MDIC, 2009. Table developed by author.

The North and northeast were aggregated in the analysis because of similarity in economic / social / cultural. The results presented in Table 03, show that there is a relevant positive correlation (R), ie, a correlation of about 76% among choosers of the MEI program and beneficiaries of federal programs.

Table 3: Calculation of the inverse linear correlation MEI X BF, in the North / Northeast

	Micro_Emp	Benef_Soci
Micro_Emp Pearson Correlation	1	,761**
Sig. (2-tailed)		0,001
N	16	16

Benef_Soci	Pearson	,761**	1
	Correlation		
	Sig. (2-tailed)	0,001	
N		16	16

There is a coefficient of correlation (R) of 0.761, a rate considered high, and a significance level of 95% (Levine, 2005). Looking at table 03, can be notice the existence of a positive linear correlation, ie the states included in the analysis, adherence to the Bolsa Familia program exhibits behaviour similar to joining the MEI program. This positive relationship is best shown in Figure 1.

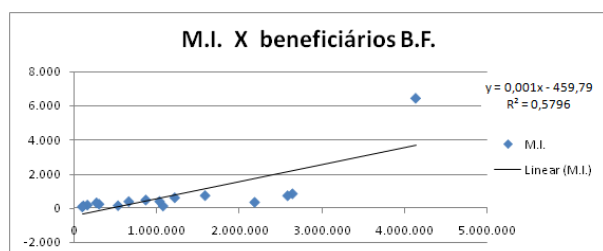


Figure 1: The inverse of the program takers beneficiaries MI X BF, in the North / Northeast

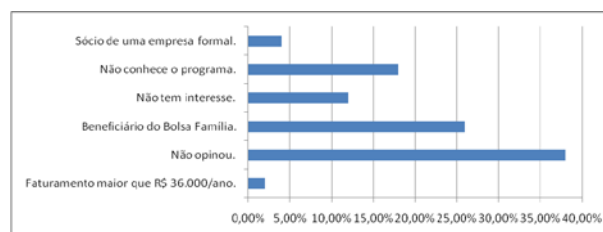
It is noticeable that the points are very close to the trendline, indicating that converges with the number of individual micro entrepreneurs, not being antagonistic (negative correlation), as provided by the consulted accounting professionals. Note also, that the points are very close to the trend line drawn by the model.

Finally, the determination coefficient (R2) that explains how much a explanatory percentage variable, part of the total variation (Ross, 1997), reaches approximately 58%, ie, the benefits of Family Allowance account for approximately 3/5 of MEI program membership in the studied region. The null hypothesis was rejected.

However, it was necessary a deeper analysis of the relationship between the two programs for the city, especially in the interior states. Studies on the analysis of the constitution of the family income - eventually the program taker can enlist any dependents of the family purse and both can enjoy the programs, as well as, provide incremental information for future studies.

Factors Identification

At the opening of the questionnaire, which requested the identification of the individual in the MEI program. Those who indicated that did not participate, were asked about the motivations for such an option. The results are highlighted in Figure 1.



Graph 1 - Motivations of participants not joining the MEI program in San Francisco Valley

Most participants, 38% preferred not to opine on the motivations for not joining the program. About 27% justified themselves because were already receiving the Bolsa Familia and fear to lose the benefit, considering that the MEI is offered exclusively to people unable to have their own income.

Another relevant reason, which comprises about 18% of the inquires, results from the lack of benefits from the legalization of the business, a fact that demands attention by the Government in order that necessary disclosure actions being performed are in fact misleading and / or ineffective.

Finally, approximately 12% of the sample has no interest, especially considering the situation of illegal workers is better than the legal ones, mainly due to the fact of not having employment contracts, lacking obligation with tax payments to the government.

With questionnaires in hand, the factor analysis procedure was performed on the data collected via forms. The first step is to check the statistical relevance of all variables, as shown in Table 4

Table 4: Significance of all variables of MEI program benefits in the Sao Francisco Valley

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,729
Bartlett's Test of Sphericity	Approx. Chi-Square	112,389
	DF	105
	Sig.	0,293

Note that, despite the occurrence of a Kaiser-Meyer-Olkin (KMO) of 0.729, a rate considered good, the overall significance level of 0.293 was well above the acceptable level of 0.05 (FIELD, 2009). It became necessary to evaluate each of the MEI program benefits offered and their significance levels, individually. According to Field (2009: 271), the KMO "represents the ratio of the squared correlation to squared partial correlation between variables", ie, the measure shows which variables relate to others. In this sense, Hutcheson and Sofronie (1999: 224-225) contribute to the KMO analysis stating that "values above 0.50 are acceptable, but mediocre, between 0.70 and 0.80 are good, and

between 0.80 to 0.90 are optimal and above 0.90 are excellent."

Another variable that requires attention is the Bartlett's test (Bartlett's Test of Sphericity) that "tests the null hypothesis that the original correlation matrix is an identity matrix (FIELD, 2009:580). In other words, the test checks if the variables are correlated or not.

In factor analysis, it is imperative a high degree of correlation between variables, thus, want to deny the null hypothesis that the matrix is identity. Looking at table 04, there is a significance level of 0.293, above the expected 0.05. It is therefore concerned that the matrix is identity, which makes the process of extraction of factors not viable.

Individual analysis of the benefits of KMO, five showed statistical insignificance, namely exemption from registration fees and license free; obligation to deliver single statement, opportunity for growth as an entrepreneur, selling to government and legal security. Although insignificant in the sample studied, the five excluded benefits require some reflections to be taken into consideration. Exemption from registration fees and free license does not involve a large informal economy workers, thereby possibly can justify its insignificance when compared to other benefits.

The obligation to deliver single declaration is not interesting because they are not completely free of state government revenue declaration, requiring them to declare once / year the amount sold every month.

As to the possibility of grow as an entrepreneur, is not interesting because of the very legal restriction that limits the program's maximum revenues in R \$ 36,000.00 per year. In a scenario of progressive growth, the declassification of the program becomes imminent, and migration to the Single National necessary, causing the loss of benefits, especially the reduction of taxes derived from the MEI program.

When it comes to selling to the government, for the micro entrepreneur this benefit may not be desired, especially by the intrinsic difficulty of participating in lengthy procurement processes that require, among other requirements, issuing of invoice, which necessarily entails gathering in taxes due and presses the income ceiling for the maximum allowed by the program. In this scenario, it becomes more interesting to concentrate sales to individuals in order waiving the issuance of invoices.

Other issues also relevant in relation to sales to the government, is the bureaucracy. The need to keep documentation up to date, for regular tax and the necessary agility to made the documentation available for presentation in tenders. All this without addressing the gap between the average terms offered by suppliers and obtained / demanded by the government, which necessarily entails the lack of synchronization between receipts and cash disbursements from. This last scenario ends in the detention of additional own resources and /

or third party fundraising for working capital in order to avoid problems with suppliers, mainly from shortages.

As regards legal certainty, it is a civil right guaranteed by the Constitution, seeking stability and protection against sudden changes in a law. In this context, the benefit does not add much, compared to the previous scenario.

Filled this gap, after removing the five insignificant variables, a new factor analysis was performed. Evaluating again the statistical significance of the variables (10 in total now), we obtained a satisfactory outcome to a significance level of 5%, according to table 5.

Table 5: Significance of the 10 remaining variables of MEI program benefits in the Sao Francisco

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,718
Bartlett's Test of Sphericity	Approx. Chi-Square	85,698
	DF	45
	Sig.	0,000

Note that although the Kaiser-Meyer-Olkin (KMO) suffered mild abduction, it remained above the threshold of 0.70 and, showed overall significance level of 0.000 (acceptable value) less than the significance level of 0.05 (FIELD, 2009, p.581). The next step required in the analysis was to verify the Kaiser-Meyer-Olkin (KMO) diagonal matrix of the anti-image correlations, as shown in table 6.

Table 6: Anti-Image Matrix of the remaining variables of MEI program benefits in the Sao Francisco

Cobertura Previdenciária	,635*	-0,334	-0,058	0,129	0,021	0,013	-0,03	-0,113	-0,254	-0,192
Registro de Funcionários	-0,334	,710*	-0,004	0,195	-0,035	-0,054	-0,317	0,15	-0,108	0,183
Possibilidade de obter crédito junto à bancos	-0,058	-0,004	,789*	-0,134	-0,178	0,175	-0,059	0,079	-0,123	0,021
União de empreendedores para compras conjuntas	0,129	0,195	-0,134	,663*	0,015	0,059	0,019	0,133	-0,019	0,208
Baixo custo de formalização (ICMS e ISS)	0,021	-0,035	-0,178	0,015	,706*	0,019	-0,327	0,08	0,094	-0,101
Controles Simplificados	0,013	-0,054	0,175	0,059	0,019	,764*	0,02	-0,081	0,053	-0,195
Inexistência de taxas de abertura e gratuidade de Alvará	-0,03	-0,317	-0,059	0,019	-0,327	0,02	,736*	0,271	-0,075	-0,07
Cidadania	-0,113	0,15	0,079	0,133	0,08	-0,081	0,271	,783*	0,071	-0,168
Assessoria contábil gratuita para registro da empresa	-0,254	-0,108	-0,123	-0,019	0,094	0,053	-0,075	0,071	,757*	0,183
Apoio técnico do SEBRAE	-0,192	0,183	0,021	0,208	-0,101	-0,195	-0,07	-0,168	0,183	,624*

According to Field (2009, p. 280): "Beyond the KMO statistics, it is also important to examine the diagonal elements of the array of anti-image correlation: the value must be above a minimum of 0.50 for all variables. Analyzing the values, all figures hover above this threshold satisfying the minimum requirement for validation of the variables.

Table 7 shows the auto-values associated with each benefit before extraction (10 factors), after extraction (6 factors) and after rotation (factors remained 6).

Table7: Total variance explained of the MEI Program Benefits, the San Francisco Valley

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2,734	27,341	27,341	2,734	27,341	27,341	1,935	19,352	19,352
2	1,784	17,838	45,18	1,784	17,838	45,18	1,61	16,102	35,453
3	1,183	11,83	57,009	1,183	11,83	57,009	1,348	13,476	48,929
4	0,907	9,068	66,077	0,907	9,068	66,077	1,081	10,815	59,744
5	0,768	7,684	73,761	0,768	7,684	73,761	1,022	10,222	69,966
6	0,618	6,178	79,94	0,618	6,178	79,94	0,997	9,974	79,94
7	0,585	5,854	85,793						
8	0,577	5,769	91,562						
9	0,463	4,633	96,195						
10	0,381	3,805	100						

According to Field (2009:580): "The rotation has one optimizing effect on the factor structure and in consequence for data is that factors relative importance is equalized." Before the procedure, the first factor, for example, was responsible for 27.34% of total variance (Cumulative%), after extraction, its explanatory power fell to 19.352% however with the five removed factors an synergetic effect is detected that ensures the explanation of approximately 79.94% of total variation across the sample.

Table 08 presents the communality of each benefit, ie the share the common variation present within each variable (FIELD, 2009:262). In other words, the communalities show the proportion of each variable that is common to the other, or how much each variable explains this phenomenon.

Table 8: 10 Benefits of commonalities relevant to the MEI program in the San Francisco Valley.
Source: Output of SPSS software

	Initial	Extraction
Cobertura Previdenciária	1	0,812
Registro de Funcionários	1	0,716
Possibilidade de obter crédito junto à bancos	1	0,933
União de empreendedores para compras conjuntas	1	0,954
Baixo custo de formalização (ICMS e ISS)	1	0,719
Controles Simplificados	1	0,99
Inexistência de taxas de abertura e gratuidade de Alvará	1	0,726
Cidadania	1	0,663
Assessoria contábil gratuita para registro da empresa	1	0,693
Apoio técnico do SEBRAE	1	0,788

Analyzing Table 8, it can be stated that 81.2% of the variance is associated with benefit one and can be common or shared, in other words, the factor of social

security coverage reflects approximately 81% of common aspirations to all other factors. This information is useful to understand the purpose of factorial analysis:

Before extraction, there are as many factors as variables, so all variance is explained by the factors and all communities are 1. However, after extracting some of the factors are discarded and some information is lost. The retained factors can not explain all variation in the data, but can explain most (FIELD, 2009:582).

Table 9 presents six variables called constructs, which condense the 10 remaining benefits. Although unable to explain all the variation, it is successful in approximately 80%. Field (2009:582) states: "After the factors were extracted, we have a better idea of how much variance is actually common."

The six factors in question are not sufficient to explain all the variation present however, explain a substantial part. The amount of explained variable and related to other variables is presented in Table 9.

Table 9: Reproduced Correlations of the MEI program Benefits in the San

Reproduced Correlation	Cobertura Previdenciária	.812*	0,483	0,065	.251	0,066	.029	0,282	0,049	0,478	0,255
	Registro de Funcionários	0,483	.716*	0,11	.294	0,262	.041	.0582	.0413	0,453	.175
	Possibilidade de obter crédito junto à bancos	0,065	0,11	.933*	.142	0,374	.262	.23	.0218	0,343	.184
	União de empreendedores para compras conjuntas	.251	.294	.142	.954*	.018	.175	.049	.0251	0,086	.263
	Baixo custo de formalização (ICMS e ISS)	0,066	0,262	0,374	.018	.719*	.096	.0581	.0362	0,073	.171
	Controles Simplificados	.029	.041	.262	.175	.096	.990*	.106	.0214	.128	.325
	Inexistência de taxas de abertura e gratuidade de Alvará	0,282	.0582	.23	.049	.0581	.106	.726*	-.055	.23	.072
	Cidadania	0,049	.0413	.0218	.0251	.0362	.0214	-.055	.663*	.243	.45
	Assessoria contábil gratuita para registro da empresa	0,478	0,453	0,343	0,086	.073	.128	.23	.0243	.693*	.332
	Apoio técnico do SEBRAE	0,255	.175	.184	.263	.171	.325	.072	.45	.332	.788*
Residual*	Cobertura Previdenciária		.053	.032	.001	.02	.041	.054	.057	.165	.128
	Registro de Funcionários	.053		.056	.1	-.03	.013	.084	.094	.122	.025
	Possibilidade de obter crédito junto à bancos	.032	.056		.021	.115	.001	.021	.044	.116	.027
	União de empreendedores para compras conjuntas	.001	.1	.021		.003	.002	.004	.078	.068	.031
	Baixo custo de formalização (ICMS e ISS)	.02	-.03	.115	.003		.017	.138	.108	.115	.135
	Controles Simplificados	.041	.013	.001	.002	.017		.008	.005	.032	-.04
	Inexistência de taxas de abertura e gratuidade de Alvará	.054	.084	.021	.004	.138	.008		.117	.017	.001
	Cidadania	.057	.094	.044	.078	.108	.005	.117		.011	.149
	Assessoria contábil gratuita para registro da empresa	.165	.122	.116	.068	.115	.032	.017	.011		.09
	Apoio técnico do SEBRAE	.128	.025	.027	.031	.135	-.04	.001	.149	.09	

At the top of Table 9 it is showed the coefficient correlation between all remaining benefits. Actually, this is a re-reading of table 05 after the factor extraction, ie is an "application of the factors extraction model to

explain the phenomenon in detriment of the observed data" (FIELD, 2009:587)

To verify the model fit, one should examine the bottom of the table which presents the residual values (difference between the value predicted by the model and the value observed) (GUJARATI, 2000). The divergence between the two scenarios was: 21 occurrences, 46%, which is acceptable being the "ceiling of 50% for acceptance of the model as appropriate", ie consider it as valid (op cit, 2009:587). Table 10 shows the auto-values associated with each benefit after the rotation of the 10 factors correlated to actual six constructs.

Table 10 – Rotation of Matrix Components (Factors) of the MEI program Benefits in the San Francisco

	Component					
	1	2	3	4	5	6
Inexistência de taxas de abertura e gratuidade de Alvará	0,809					
Baixo custo de formalização (ICMS e ISS)	0,752					
Cidadania	-0,629		0,472			
Cobertura Previdenciária		0,829				
Assessoria contábil gratuita para registro da empresa		0,717				
Registro de Funcionários	0,517	0,555				
Apoio técnico do SEBRAE			0,861			
União de empreendedores para compras conjuntas				0,955		
Possibilidade de obter crédito junto a bancos					0,926	
Controles Simplificados						0,968

According to Field (2009:589) Table 10 shows that the initial questionnaire was comprised by 15 benefits in fact representing six constructs, qualities sought by those who choose to join the program.

The next step was to identify the constructs extracted and presented in Table 10. The maximum value being obtained by a variable was 1, so the values close to this threshold were more relevant than others (FIELD, 2009). For Field (2009:589): "if the produced mathematical factor analysis represents a real construct, common themes among the questions with high loads can help us identify what the construct may be."

The 6 (six) construct obtained and analyzed are presented in Table 11 below.

Table 11 - Factors in the MEI program envisioned by the applicants, the Sao Francisco Valley

Fatores	Construtos
Fator 1	Economia de Custos
Fator 2	Benefícios Adquiridos
Fator 3	Realização/Auto-estima
Fator 4	Condições de crescimento
Fator 5	Economia na captação de recursos
Fator 6	Formalização sem burocracia

Looking more closely at Table 10, you may notice in factor one the grouping of benefits, no fees of opening, no pay supplement in licence, low registration cost

(ICMS and ISS) and employees registration, all showing positive values, indicating that they are measuring the same trait. It is clearly understood that they are linked to issues of cost reduction, known as the construct real "cost savings", which represents the intention to reduce organizational costs after registration.

Regarding the second factor, it represents the real construct, "acquired benefits" in order that larger loads are given social security benefits, free accounting advice for company registration and employee record. The latter appears in the first two constructs; however it appears more relevant in the second factor, than in the first one, where is more linked to acquired benefits than cost savings. This factor represents the desire for access rights to be acquired by MEI, when joining the program. The third factor that realizes the benefits of citizenship and technical support SEBRAE was termed as "achievement / self-esteem" construct. It is related to the right of dignity, professional, personal and social self-realization; the citizen can get fulfilled working, with dignity, citizenship, and according to the laws in force and may even rely on technical support from SEBRAE, with guidance and training to become better able to realize and develop their skills and, by extension, to perpetuate the feeling of self-realization.

Factor 4 has only the benefit of the entrepreneurs union for joint purchases, which was characterized as the construct of "Terms of growth," it provides to entrepreneurs, the most advantageous terms, especially as regards to the prices and terms of payment of goods purchased in view of the forthcoming volume of purchases.

The fifth factor, as well as the fourth, includes only one benefit: Ability to obtain credit from banks. There is a clear need, and especially the intention of raising funds from banks to finance small businesses; so the construct was called "Economics in fundraising." With access to the MEI program, it becomes really possible for the entrepreneur to obtain bank loans with significantly lower costs (fees and interest rates appropriate for the individual micro entrepreneur in detriment to the funds raised by non official).

Finally, the sixth factor is the bureaucracy free processes through simplified controls with a high load of 0.96. The construct was termed as "non-bureaucratic registration" taking in account the lack of need for formal accounting requirement, following the registration, only a single statement in annual sales through the Internet.

CONCLUSIONS AND FURTHER RESEARCH

The Individual Micro Entrepreneur program arose with the need to regularize the millions of illegal businesses in the country. The government created the program with many benefits to promote / encourage the underground sector to give up their situation, bearing in mind that the size of the underground economy moved about 18% of GDP.

This scenario is comes in part due to high tax burden on business activities, unemployment rates and the various bureaucracies required by government institutions to normally register businesses. So until then, there was not another option for small entrepreneurs but to opt for illegality.

The main objective of this research was to study the motivation that leads illegal workers of the São Francisco Valley to join the individual Micro enterprising program. This work noted that the fifteen (15) benefits offered by the program, five (5) were not significant, ie were not desired by the sample studied.

Because of the irrelevance of those five (5) benefits, subsidies require costs to the Government, at the time a series of grants is carried out by it, resulting in inefficiency of public spending.

The ten (10) benefits that showed to be significant are related to legal issues, tax, pension and labour those are considered indispensable to its success. After a new rotation it was possible to condense the ten (10) benefits in six (6) factors. Being regarded as "real constructs", those factors explain more clearly the desire of illegal workers to join the individual Micro entrepreneur program.

The constructs found were named: cost savings, acquire benefits, performance / self-esteem, growth conditions, economy in fundraising and non-bureaucratic registration. In other words, these factors reveal the common themes pursued and, consequently sought by MEI program participants.

Given the presented scenario, and with the intention of study the subject in focus, ie, the MEI program and beneficiaries of Bolsa Familia, it is recommended that further analysis of the relationship between the two programs by city, especially the interior, be made. When focus on establishment of family income and hence, the opportunities of the applicants enlist any dependents in the family purse, taking advantage from both programs, still leave large questions for the future, leaving the perspective of knowledge reconstruction that may contribute to other scholars who would like to deepen the problem in question.

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THE NEED FOR A NEW SUSTAINABLE ECONOMIC MODEL

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ABSTRACT

Following the subprime mortgage problems that started in the United States (US) in the second half of the 2000's, the world would suffer the first financial crash shockwave of the 21st century, when the quasi collapse of the banking system in the US, occurred in September 2008, threatened the entire global financial network. The seriousness of the financial crisis became clear as it swiftly contaminated the major developed economies. Quarterly GDP growth turned sharply negative, in many cases reaching a two-digit decrease; and every major macroeconomic indicator, such as industrial production, household income, or exports, suffered significant decreases. Understandably, the atonished general public started to questioning the current economic model.

In this paper it is argued that Marx was wrong: the dialectic of the social classes' clashes will not result in capitalism failure. Instead, sustainable issues will force capitalism to reshape in order to prevent the collapse of the humanity, which can only afford to live in a single planet, from which depends totally. This is significant for the way business is conducted, as even sustainable businesses may turn unsustainable if the planet collapses, being probably this the most likely reason to believe that a new sustainable model may be critical for mankind.

INTRODUCTION

"We live in a dangerous world" is a commonplace sentence, often used to describe a status of uncertainty and peril. From terrorist attacks to internet threats, this quote can also be adopted for the current economic condition.

Following the subprime mortgage problems that started in the US in the second half of the 2000's, the world would suffer the first financial crash shockwave of the 21st century, when the quasi collapse of the banking system in the US, occurred in September 2008, threatened the entire global financial network. The seriousness of the financial crisis became clear as it

swiftly contaminated the major developed economies. Quarterly GDP growth turned sharply negative, in many cases reaching a two-digit decrease; and every major macroeconomic indicator, such as industrial production, household income, or exports, suffered significant decreases.

Understandably, the atonished general public started to questioning the current economic model. Of particular criticism, the role of the financial system in the economic model, and the need of rescue at taxpayers' expenses.

Indeed, as the ordinary folk started to be worried about the near future, many started also questioning the dominant economic model, based on capitalism and free markets. Some have, inclusively, asked for the return of communism: come back Marx, after all you were right. It seems arguable that the existing economic model has serious drawbacks, but it is the case for a return of Marx? I believe that certainly not. Despite the current turmoil, the basic foundations of capitalism – private ownership and accumulation of capital as a mean of economic growth – will continue sound. The Marxist economic experience under the form of Communism resulted catastrophic as proved by the Berlin's Wall fall and by the collapse of the USSR. The current crisis, which is not merely economic, will reinforce the meaning of Hegel's dialectic, but will not end in the ultimate destruction of capitalism as a result of internal convulsions, as predicted by Marx (1848 with Engels, 1867). Indeed, while capitalism faced several crises and prevailed, the lifetime of Communism was considerably short in historical terms, only seven decades. Marx will remain buried, while Lenin will probably be hoping to continue to rest in peace in the everlasting and fashionable Red Square mausoleum, as many capitalism-converted Russians keep arguing that the leader of the Russian revolution should be simply buried, ending any kind of morbid worship.

If communism does not seem an appropriate exit for this crisis, what about a refoundation of capitalism, coming back to the Keynesians models? Hopefully not. At least in a radical fashion. Digging holes or building holes as a mean to contain unemployment is not certainly the best

policy to stimulate a sustainable economy. Resources are scarce and the human activity effects on the planet are becoming increasingly problematic. Nevertheless, socialism is not dead and Roosevelt's New Deal was critical in the 1930's to save the USA from the Great Depression, in a time when unemployment reached unimaginable levels. Keynesianism became the economic paradigm of social welfare, but failed to ensure sustainability, as proved by the 1970's turbulence. Indeed, the increasing role of the government in the economy resulted in significant inefficiencies, which became more visible with the 1973 oil crisis and the subsequent inflationary process. Although a Keynesian strategy seems to be an interesting solution in the very short term for exiting the current crisis, as expansionary monetary and budgeting policies are battling the current deflationary environment in long term assets category, the reality is that this strategy is like fighting the fire with gasoline. Indeed, fighting deflation with inflation will never be a sustainable policy, as proved by the recent increase in commodities prices, from energy to agriculture.

Given that communism failed, and also given that socialist way seems very unlikely to ever lead to communism, are we then condemned to have a single capitalistic model? And if Keynesianism seems unsustainable in the long term, are we then forced to continue to accept the neo-liberal theories, which were exactly the ones who brought us to the current economic-financial crisis? As the budgetary issues will continue to constitute a problem for most developed countries, particularly to the economies that have a deficit in their trade balance, the economic policies will continue to rely mostly in the monetary policy, keeping an abundant supply of money, and making it affordable through quantitative easing. Therefore, it seems that neo-liberalism is to be continued, alongside with globalization, meaning free trade and free markets, and ensuring that less developed and emerging countries will be able to continue experiencing economic growth. In resume, this means "business as usual" (vid. e.g. Rasor, 2000, in what relates to recurrent liberalism dominance in Western countries, led by notorious "new liberals", such as Winston Churchill).

As we are slowly recovering from the financial crisis, the increasing perception is that this event was an "ordinary" thing, just like any ordinary business cycle, something which is intrinsic to economics, being a common phenomenon in capitalism. If so, the humanity may be making a critical mistake. The period of the industrial revolution is only a brief time frame in mankind's timeline. Nevertheless, the consequences of the human activities seem obvious. Even if it may be debatable whether there is climate changing, or whether humans have something to do with glaciers and ice polar melting, no one can, however, deny that the human

activities were responsible for an exponential increase in CO2 emissions in a few centuries only. And certainly that such increase had, has, and will probably have a significant impact in the planet.

In this paper it is argued that Marx was wrong: the dialectic of the social classes' clashes will not result in capitalism failure. Instead, sustainable issues will force capitalism to reshape in order to prevent the collapse of the humanity, which can only afford to live in a single planet, from which depends totally. This is significant for the way business is conducted, as even sustainable businesses may turn unsustainable if the planet collapses, being probably this the most likely reason to believe that a new sustainable model may be critical for mankind.

THE SUBPRIME MORTGAGE ISSUE: THE HERALD FOR A FINANCIAL CRISIS

The current of economic recession resembles other crises occurred in a recent decades, but, on the other end, is clearly distinguishable from them because it marks the end of an era of credit expansion, with the dollar as international currency reference. According to Bewick (2009), previous periodic crises were part of a broader process advance-decline while the current crisis is the culmination of a huge economic boom that lasted over twenty-five years.

As Bryant & McGrath (2007) refer, owning a home has long been touted as a way of making the "American dream" a palpable opportunity that the economy would ideally be able to provide to every working family. However, several factors in the complex financial system, which have benefited from historical low interest rates and which have eased lending, caused the housing market in the US to go through a dramatic boom and bust during the first decade of the 2000s.

Following the dot.com bubble burst, and the consequent crash in the markets occurred in 2000, resulting in a particularly sharp fall in the NASDAQ, the US Federal Reserve (FED) started a very aggressive expansionary monetary policy. This type of policies were also adopted by other central banks worldwide, even if more moderately in most cases. Such abundance of money flow, powered by very low interest rates, would end in massive speculative bubbles, particularly in the housing market, leading to an historical rise of debt from households, from which companies and governments have benefited, and resulting also in a increase of debt from both the public and the private sectors.

One of the factors that caused both the rise and dramatic fall of the housing market was the use of tricky lending programs, called subprime mortgages, which enabled people with wobbly credit ratings to ensure –and secure

- home loans, being such practice of lending money to people with a weak or limited credit history called subprime lending. (vid. e.g. Demyanyk & Van Hemert, 2009; Bryant & McGrath, 2007).

These sub-prime mortgages allow people with poor credit a chance to get into a market previously unavailable to them with standard home loans. The downside of this scenario is that these loans are more likely to go into default, meaning that the borrower fails to make payments on the loan. The main feature of these loans is low interest rates. Those alongside large inflows of foreign funds created easy credit conditions for a number of years prior to the crisis, fuelling a housing market boom and encouraging debt-financed consumption. (Global Macroeconomics Team, 2010). The USA home ownership rate increased from 64% in 1994 to an all-time high of 69.2% in 2004. On the other side between 1997 and 2006, the price of the typical American house increased by 124%. While housing prices were increasing, consumers were saving less and both borrowing and spending more. From 2001 to 2007, U.S. mortgage debt almost doubled, and the amount of mortgage debt per household rose more than 63%, from \$91,500 to \$149,500, with essentially stagnant wages.

This credit and house price explosion led to a building boom and eventually to a surplus of unsold homes, which caused U.S. housing prices to peak and begin declining in mid-2006. Easy credit, and a belief that house prices would continue to appreciate, had encouraged many subprime borrowers to obtain adjustable-rate mortgages. These mortgages enticed borrowers with a below market interest rate for some predetermined period, followed by market interest rates for the remainder of the mortgage's term (Rao, 2011).

Borrowers, who would not be able to make the higher payments once the initial grace period ended, were planning to refinance their mortgages after a year or two of appreciation. But refinancing became more difficult, once house prices began to decline in many parts of the USA. Borrowers who found themselves unable to escape higher monthly payments by refinancing began to default. As more borrowers stop paying their mortgage payments foreclosures and the supply of homes for sale increases. By September 2008, average U.S. housing prices had declined by over 20% from their mid-2006 peak. This major and unexpected decline in house prices means that many borrowers have zero or negative equity in their homes, meaning their homes were worth less than their mortgages (vid. e.g. Kumar, 2010; Gerardi et al., 2009).

Economist Stan Leibowitz (2009) argued in the Wall Street Journal that although only 12% of homes had negative equity, they comprised 47% of foreclosures during the second half of 2008. He concluded that the

extent of equity in the home was the key factor in foreclosure, rather than the type of loan, credit worthiness of the borrower, or ability to pay (Leibowitz, 2009).

In response to this troubling situation, the Bush administration pushed for a voluntary freeze on interest rates for a select group of roughly 600,000 borrowers with subprime hybrid mortgages in an effort to prevent foreclosures (Barth et al., 2008). To head off similar problems in the future, some members of Congress are considering legislation that would effectively require lenders to extend mortgage loans only to individuals who can afford them. The Federal Reserve is also proposing new guidelines for mortgage lenders to better assure that only creditworthy borrowers obtain loans. Lenders are also reacting by discontinuing certain types of mortgage products and being more diligent in scrutinizing borrowers.

Despite the measures of the US Government, by then under Bush administration, and the efforts of other institutions, it was impossible to avoid the quasi collapse of the banking system in September 2008 and with it the beginning of a global crisis.

HISTORY REPEATS ITSELF: FROM OVERLEVERAGED TO INSOLVENT OR THE BEGINNING OF A ECONOMIC AND FINANCIAL CRISIS

As Mathiason & Stewart (2008) note, 2008 was the year the neo-liberal economic orthodoxy that ran the world for 30 years suffered a heart attack of epic proportions. For the first two months of the year, there was an eerie calm. A global economic meltdown still seemed unimaginable to many, even Rupert Murdoch's economic brain Irwin Stelzer refused to countenance that the financial world was spinning off its axis, but in the next months everything changed. In August 2008 financial firms around the globe have written down their holdings of subprime related securities by US\$501 billion (Mathiason & Stewart, 2008).

McAfee & Johnson (2010) pinpoint that the IMF estimates that financial institutions around the globe will eventually have to write off \$1.5 trillion of their holdings of subprime MBSs. These losses have wiped out much of the capital of the world banking system. In September 2008 Lehman Brothers and other financial institutions as Merrill Lynch, AIG, Freddie Mac, Fannie Mae, HBOS, Royal Bank of Scotland, Bradford & Bingley, Fortis, Hypo and Alliance & Leicester went bankrupt; being withdrawn from USA money funds around \$150 billion (McAfee & Johnson, 2010).

The response of the US Federal Reserve, the European Central Bank, and other central banks was immediate

and dramatic. During the last quarter of 2008, these central banks purchased US\$2.5 trillion of government debt and troubled private assets from banks (Mathiason, 2008). This was the largest liquidity injection into the credit market, and the largest monetary policy action, in world history. The governments of European nations and the USA also raised the capital of their national banking systems by \$1.5 trillion, by purchasing newly issued preferred stock in their major banks (Mathiason, 2008).

However, some economists state that Third-World economies, such as the Brazilian and Chinese ones, will not suffer as much as those from more developed countries. The International Monetary Fund estimated that large U.S. and European banks lost more than \$1 trillion on toxic assets and from bad loans from January 2007 to September 2009. These losses are expected to still increase.

From 2008, since the financial and economic crisis deepens, ordinary folk has started questioning the existing economic model, based on capitalism and free markets. Some people inclusively asked for the return of Marx and others for Keynes, but it seems that any of them is a good idea.

THE FINANCIAL SYSTEM AT PERIL: THE NEED TO GO BACK TO MARX?

Karl Heinrich Marx was a German philosopher, political economist, historian, political theorist, sociologist and revolutionary communist. In the 19 century with his friend Friedrich Engels he developed a theory called Marxism.

This doctrine, inspired in Hegelian dialectic, consists fundamentally of two interrelated ideas: a philosophical view of man and a theory of history. As Mehring (2003) refers, Hegel sees history as a story of man's alienation from himself where the spirit (God), is the "true" nature of man, and man must bring the spirit (God) back into himself through the powers of thought while Marx regards God or spirit as the *projection* of man's "true" self. To understand the true self of man, he argues, one must understand his "real," social, material conditions (Mehring, 2003). He states: "It is not the consciousness of men that determines their being, but, on the contrary, their social being that determines their consciousness" (Karl Marx, 1978).

From this idea, Marx proposes to understand the alienated state of man through an understanding of what he terms "historical materialism." By understanding the material conditions of man through history, man can come to understand his social and political conditions. (Karl Marx, 1978). In other words humans are not motivated by grand ideas but instead by material

concerns, like the need to eat and survive. This is the basic premise of a materialist view of history.

Taking the idea that social change occurs because of the struggle between different classes within society who are under contradiction one against the other, the Marxist analysis leads to the conclusion that capitalism, the currently dominant form of economic management, leads to the oppression of the proletariat, who not only make up the majority of the world's populace but who also spend their lives working for the benefit of the bourgeoisie, or the wealthy ruling class in society. To correct this inequality between the bourgeoisie and the proletariat, Marxism advocates and believes in a proletarian revolution, when the proletariat take control of government and implement reforms to benefit their class, namely the confiscation of private property which is then taken under state control and run for the benefit of the people rather than for the interests of private profit (Karl Marx, 1978).

Such a system is socialism, although Marxists believe that eventually a socialist society would develop into an entirely classless system, which is known as communism in Marxist thought. The man who established the world's first officially socialist state was Vladimir Ilyich Lenin, a Russian Marxist revolutionary, leader of the 1917 October Revolution founder of the USSR and later creator of the Soviet Communist Party (Volkogonov, 1994).

At the same time that in Russia the Socialist system evolved to Communism this happened in the rest of Europe. The end of this new political and economical system in the most European countries will be in 1989. For example, in Germany the fall of the Berlin's wall means the end of the Communism. Nowadays is very common to confuse Communism and Socialism because both have many similarities as well as many differences. The main differences are (vid. e.g. Kesselman et al., 2009):

- Socialism generally refers to an economic system, while communism generally refers to both an economic and a political system.
- Socialism seeks to manage the economy through deliberate and collective social control while Communism seeks to manage both the economy and the society by ensuring that property is owned collectively, and that control over the distribution of property is centralized in order to achieve both classlessness and statelessness.
- Socialism states the distribution of goods and services takes place according to the individuals' efforts while Communism states the distribution of goods and services takes place according to the individuals needs where.

Both socialism and communism are similar in that they seek to prevent the ill effects that are sometimes produced by capitalism.

Returning to the main paper topic, in my opinion is not a good idea come back to the Communism as a exit from the current crisis and even if tried we couldn't because this will suppose to have a common goal, to be isolate and in this shrinking world to maintain cultural isolation is impossible. On the other hand Communism provides all participants with a fair share of the workload and resources. This works well for small communities, particularly for non-diversified societies.

As we could experience on our own both capitalism and communism are poor ways of managing the use of resources .Communism over-controls while capitalism under-controls. Communism suffers from scarcity, capitalism from over consumption (Needham & Dransfield, 1999).

Maybe our Capitalistic system is not the solution for the current crisis but much less the Communism. From my point of view the best solution we have is to improve our Capitalistic system but the question is ... how? Maybe increasing the competition and diversity, educating the elite to the systemic benefits of resource distribution, and encouraging incentives for such distribution, creating secondary social mechanisms to support those that do not "fit" in the socio-economic system, encouraging the inclusion of all members of the population to compete, and opening up competition to external markets, in order to maximize diversity and flexibility, etc (Free, 1995). Nevertheless, other people ask for the return of Keynesianism as a solution to the current crisis.

THE FAILURE OF THE NEOLIBERAL MONETARY POLICY: THE RETURN OF KEYNES?

John Maynard Keynes was a British Economist whose ideas have profoundly affected the theory and practice of modern macroeconomics, as well as the economic policies of governments. In the 1930s he developed a theory known as the Keynesianism or the Keynesian theory trying to explain the causes of the Great Depression. To explain them he started analyzing why recessions happened (Moggridge, 1995).

A normal economy, with a high level of employment, is a circular flow of money as my spending becomes part of your earnings, and your spending becomes part of my earnings. But suppose something happens to shake consumer confidence in the economy. Worried consumers may then try to weather the coming economic hardship by saving their money. But because my spending is part of your earnings, my decision to hoard money makes things worse for you. And you,

responding to your own difficult times, will start hoarding money too, making things even worse for me. So there's a vicious circle at work here: people hoard money in difficult times, but times become more difficult when people hoard money (Keynes, 2010). The cure for this, Keynes said, was for the central bank to expand the money supply. By putting more bills in people's hands, consumer confidence would return, people would spend, and the circular flow of money would be re-established.

On the other hand Keynes believed that depressions were recessions that had fallen into a "liquidity trap." A liquidity trap is when people hoard money and refuse to spend no matter how much the government tries to expand the money supply. In these dire circumstances, Keynes believed that the government should do what individuals were not, namely, spend. (Keynes, 2010; DeLong, 2009). In other words Keynes argued that lower aggregate expenditures in the economy contributed to a massive decline in income and employment. In such a situation, the economy reached equilibrium at low levels of economic activity and high unemployment. The cure was to keep people fully employed and for that governments have to run deficits by increasing their spending and/or cutting taxes. Keynes' advice on ending the Great Depression was not very much welcomed by US president Roosevelt.

Almost all economists agree that World War II cured the Great Depression; Keynesians believe this was so because the U.S. finally began massive public spending on defence. This is a large part of the reason why "wars are good for the economy" (Krugman, Lawrence, Barnes, Donahue, Forbes & Kapstein, 1996). Following the outbreak of World War II, Keynes's ideas concerning economic policy were adopted by leading Western economies. During the 1950s and 1960s, the success of Keynesian economics resulted in almost all capitalist governments adopting its policy recommendations, promoting the cause of social liberalism.

Keynesian economics advocates that the economy should be a mixed economy, predominantly private sector, but with a large role of the government and the public sector. He argues that private sector decisions sometimes lead to inefficient macroeconomic outcomes and therefore advocates active policy responses by the public sector, including monetary policy actions by the central bank and fiscal policy actions by the government to stabilize output over the business cycle and reduce unemployment (Keynes, 2010). Control of the money supply, interest rates and adjust the governments spending could influence investment.

Keynesian economics also warns against the practice of too much saving, or under consumption, and not enough

consumption, or spending, in the economy. It also supports considerable redistribution of wealth, when needed. Keynesian economics further concludes that there is a pragmatic reason for the massive redistribution of wealth: if the poorer segments of society are given sums of money, they will likely spend it, rather than save it, thus promoting economic growth.

Nowadays due to the financial crisis Keynes theory is back into the economic debate. The causes of this crisis are different. In others opinion it is a continuation of the Keynesian crisis of 1970s, when, in response to “wage inflation”, and amidst competitive pressures and expansion of democratic business “went on strike” against unionised labour and social democracy.

Some Keynesian economists attribute the root of this crisis to deregulation and innovation in the financial sector which were supported by the efficient market hypothesis and to distortion of the incentive structure which came from deregulations and innovations. They ask for more regulations and supervision of financial activities and more active fiscal stimulus as recovery policy is needed (Mayes, Morgan & Lim, 2010).

Others think that the causes of the crisis are the lack of resources in the banks to maintain the credit system flowing so that companies that depend on the banking system can survive. Another cause is the huge stocks of worthless option, derivatives and mortgage backed securities, which are now reduced to the status of junk bonds. Here appears Keynes short term strategy of throwing money to the banks and the companies. (Basu, 2008). Like the text mentions, this strategy is like fighting fire with gasoline or inflation with deflation and it is proved that will not solve the problem, as the US government is trying to do now.

Nationalisation of the entire banking system along with the major companies is needed to solve this problem. Nationalisation will help the government to refinance the depleted stock of the banks and to help major companies to survive. That will help their supplier companies and their sales outlets along with the trading companies to survive. It is essential for the governments of most countries to understand that even during the last great depression, the mass unemployment took place about two years after collapse of the stock market in 1929 (Basu, 2008).

Keynes also developed a long-term solution to the crisis. In 1948 he suggested to redesign the world's financial architecture. The idea is that no country will be allowed to keep more than a certain amount of its surplus from the balance of payments. Today, China's reserve of foreign currencies has exceeded a trillion US Dollar causing blockages of the financial flows. Keynes idea was that the member countries of the IMF might

keep up to one year's import costs as reserve of foreign currency. The rest they have to deposit to the IMF, so that these surplus can be distributed to the countries in need of investments. Unfortunately his strategy doesn't work as the IMF is controlled by the American financiers who do not accept these restrictions (Basu, 2008).

THE NEED FOR A NEW SUSTAINABLE ECONOMIC MODEL

Sustainable development has become a subject of major attention in almost all countries. It involves finding a balance between the exploitation of natural resources to meet the needs of the present generations without jeopardizing the needs of future generations. For this to happen is necessary economic development, protection of the environment and social justice in an integrated and mutually reinforcing way. So sustainable development focuses on (Bosetti, Gerlagh & Schleicher, 2009):

- High levels of employment and social cohesion
- A high level of environmental protection and responsible use of natural resources
- Balanced and equitable economic development
- Coherent policy making in an open, transparent and accountable political system
- Effective international co-operation to promote sustainable development globally

Recently the economic models were essentially concerned with the Economy's internal rational (market expectations, values of goods and services) and tend to ignore external natural constraints which may deeply affect the long-term evolution. The activities which contribute most to the average growth rate are those which most affect the environment. So for this we should use more renewable energy sources, turn off the lights or recycle our waste products. As the economist Jeffrey Sachs says this is not enough because we must have a global vision not only a local vision and countries should cooperate and implement different strategies. An example of cooperation is that the government of Norway offered a billion dollars to Brazil for a program to avoid deforestation of the Amazon forest (Sachs, 2009; Nihoul, 2009).

The continuous growth of countries has led to serious environmental problems, including biodiversity loss, desertification, an increase pollution and a higher frequency of environmental disasters such as droughts, storms or floods. One well-known example of this unsustainable development regards climate change. (Bosetti, Gerlagh & Schleicher, 2009).

Apart from the environmental problems, there are worrying trends regarding the ageing of societies in developed countries and a widening gap between the

rich and the poor in the world. Rather, more sustainable strategies need to be discovered which enable a higher development in these countries without encountering the same problems as the industrialised world. (Bosetti, Gerlagh & Schleicher, 2009)

However, development has also brought huge achievements, apart from the overall increase in per capita income a strong decrease of infant mortality and of adult illiteracy. The industrialised countries have achieved a level of per capita consumption and prosperity, higher than any time before in history (Bosetti, Gerlagh & Schleicher, 2009).

CONCLUSIONS

Today, those who have created this present crisis, the financiers of the Wall Street, are giving advice on how to solve the problem. That is the very reason the problem is not going to be solved but within the next two years the world will see mass unemployment and deprivation that would ruin a number of countries and the IMF would run out of resources to help the developing countries.

The reality is that it will take time to digest all the excessive leverage incurred in recent years. The predominant economic model will not probably change. It is either unlikely that the return to Marx or Keynes will deliver us out for the current crisis. The only option we have is to improve the neo-liberal theories that ensure at least for developed and emerging countries to continue experiencing economic growth. Nowadays people are starting thinking that this crisis is something normal in a economy but it isn't, in a economy are normal periods of recessions but the current crisis is more than a recession and it had affected all the world.

As we are recovering from it we can see the consequences of human activities something that is obvious and we can appreciate with different phenomena's like the global heat or the ice polar melting. And may force everybody to finally think about the limits of the planet, which may also represent the limits to any economic model, even if some factors, such as technological developments, may continue to overcome such limitations. But even though there will be limits. At least limitations for the number of people that the planet may comfortably accommodate, without being forced to be shaped simply according to human needs.

I believe this is an issue that will certainly need to be addressed in the future. Probably it would be more wise to address it sooner than later, as some consequences will be irreversible. However, as being aware of the human nature, I'm afraid that individual, national, and regional interests would prevail and that ultimately, the

issue of a sustainable economic model may be addressed far too late.

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SUSTAINABLE BUSINESS MODELS FOR WEB 3.0

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ABSTRACT

The information revolution created by the Internet quickly transformed communications into a vital part of business and everyday life. Currently the pervasive Internet is still evolving and is poised to enter in a new stage of development that will make it more intelligent, aware, and accessible. The next stage of the web creates the potential for individuals and organizations to use information in ways that facilitate the interoperability of devices and networks. As a consequence, companies should begin anticipating this new digital era now and prepare their organizations to compete and profit from this emerging environment. This paper looks to the semantic web and Web 3.0 technologies as enablers for the creation of value and new emergent business models. It identifies the main sources of value offered by semantic web technologies and proposes eight business models that a company can follow to adopt a successful Web 3.0 business strategy. Additionally, these business models were analysed in a long-term perspective, attending to the technologic and business risks associated with each approach and the sustainability of the generated revenues.

INTRODUCTION

The foundation for today's information services explosion was laid with Web 1.0, the read-only web. The initial system created a constantly growing library of information published on static websites, which users could access directly via browsers or discover via search engines. Web 2.0, often called the read-write web or the "social web", made the internet easy for consumers to understand and use and allowed them to participate in creating and publishing content. Users could share their ideas with others via blogs, wikis, and social networking sites, add links to information published by other communities and applications, and interact with content published by others.

Web 2.0 has become an integral part of life and business. Companies, government agencies, and other

organizations have leveraged the technology's publishing and participatory attributes to create new applications and business models for both internal and outward-facing needs (Hogg et al., 2006). However, the information contained on the web today has little structure, which limits its potential use. Web 2.0 is also constrained by the extraordinary volume of information available, the escalating rate at which content is published, and the inability of the existing system to integrate data that originates from different sources or in different formats (Hendler, 2009).

Web 3.0 faces these limitations of Web 2.0 and is generally associated with the evolution of an "intelligent web". It's anticipated that the intelligent web will address the lack of structure and organization in Web 2.0 by linking information from disparate sources and systems to make the web even easier to use, more efficient, and more valuable to its users. Web 3.0 is also referred like the "semantic web" because it will use semantics to interpret searchable content and thus deliver more appropriate and relevant content to end-users.

The most relevant differences between Web 2.0 and Web 3.0 are summarized in Table 1.

Table 1: Differences between Web 2.0 and Web 3.0
(Breslin and Decker, 2007)

	<i>Web 2.0</i>	<i>Web 3.0</i>
<i>Main task</i>	Focus the power of community to create dynamic contents and interaction technology	Linked data, devices and people across the web
<i>Linking</i>	Walled gardens inhibit interoperability	Data and devices linked more easily and in new ways
<i>Content</i>	Individual and organization create content	Individual, organization, machine create content which can be reused
<i>Technology</i>	AJAX	RDF and OWL
<i>Website</i>	Google, Facebook, Wikipedia, eBay, Youtube	Dbpedia, sioc-project.org

Web 3.0 introduces new techniques for organizing content and new tools that will make it possible for software and applications to collect, interpret, and use data in ways that can add meaning and structure to

information where it didn't exist before. In concept, Web 3.0 is able to unleash services that can cut through high volumes of information from disparate digital sources, like web content to e-mail or files residing on a PC, to deliver more relevant search results. It also offers tools to better manage flows of information, and deliver a faster and richer user experience (Hendler, 2009).

THE ROLE OF SEMANTIC WEB TECHNOLOGIES

One of the fundamental features of Web 3.0 is its capability to use unstructured information on the Web more intelligently by formulating meaning from the context in which the information is published. Specific information resources on the Web will be organized, correlated, and linked to other resources of common interest by the use of natural language processing and semantic technologies that can index data, and then find it, interpret it, and establish relationships between disparate data elements in anticipation of a user's search needs (Baumann, 2009).

An user, for example, can process text-based information in ways that are similar to the methods employed currently to process structured or numeric data from spreadsheets and databases. A search engine is able to understand queries presented as full questions and serve up accurate and relevant results, even if the results do not necessarily contain the specific search terms used. Technologies will also be able to better filter data to improve search-result quality and relevance to deliver the content that best serves the user's intentions.

Some of the semantic technologies used to make Web 3.0 possible include the Resource Description Framework (RDF), which describes information so that it can be read and understood by computer applications. Another semantic technology is the Web Ontology Language (OWL) which intends to describe the web information and relationships between web information.

In fact, OWL and RDF are similar, but OWL is a stronger language with greater machine interpretability than RDF (Miller and Hendler, 2004). Both technologies can be used to assert relationships between data obtained from individual or multiple applications or sources and merge information from previously unrelated sources (Pandey and Dwivedi, 2011).

The opportunities to integrate and mingle data introduced by these new capabilities will also make it possible for companies and organizations that deliver public and private cloud-based services to team up to deliver new products. Thus, openness between data sources has breakthrough potential to open up relationships between business and foster product and service collaborations between companies that previously may haven't the means or reasons to work together.

However, the new challenges and services that can be developed under Web 3.0 raise new concern about security aspects. In the new semantic model, the problem of understanding the personal exposure level and all the

web mechanism that provide the extensive collection of the personal data is an important issue (Cho et al., 2008). Additionally, the methodology for semantic web services discovery is a relevant research field (Zhou, 2010). The approach to semantic web services proposes an actual web service in a form that consolidate ontology and semantics. The ontologies are a relevant issue as a source for semantic representation of future services such as Web services, grid services and agent services (Khalid et al., 2008). Using this approach it is possible to access services in a dynamically manner.

SOURCES OF VALUE

Semantic technologies have the potential to drive huge improvements in capabilities and life cycle economics of business solutions through cost reductions, improved efficiencies, gains in effectiveness, and new functionalities that were not possible or economically feasible until the present time. Semantic technologies can provide significant value in the following three dimensions: capability, performance and life cycle economics.

Capabilities

Semantic model-based approaches improve development economics through the use of shared knowledge models as building blocks and autonomic software techniques, such as goal-oriented software with self-diagnostic and self-management capabilities. As a consequence, a system with more intelligence helps users perform tasks faster, provide more helpful information and interaction, and deliver a more enjoyable user experience. Adding intelligence capabilities can produce significant gains in communication effectiveness, service delivery, user productivity, and user satisfaction (Rovan et al., 2011).

Secondly, Web 3.0 and semantic web approaches enable a business to marshal distributed collective knowledge systems, social computing, net-centric operations, and semantic technologies that increase the organization's reach and speed to discover, digest, and apply knowledge. In fact, systems that can learn increase their value during the lifetime. Machine learning-driven strategies call for knowledge assets that are interpretable by both humans and computers. For example, Google developed the "Google PageRank" yields that let the user to evaluate each Webpage. This yield expresses better relevance judgments as it indexes more and more pages.

Finally, the principle drivers for semantic infrastructure and ecosystem include the economics of mobility, scale, complexity, security, interoperability, dynamic change across networks, and information sources. These identified problems are intractable at Web Scale without semantics (Muhammad et al., 2009). The corollary need is to minimize the human labor required to build, configure, and maintain ultra-scale and dynamic infrastructure.

Performance

Typically, classic motivations for new investments in technology are: efficiency gain, effectiveness gain, and strategic edge.

Semantic technologies can have a dramatic impact on labor hours, cycle time, inventory levels, operating cost, and development time and expenses. In terms of effectiveness gain, semantic technologies can drive dramatic improvements in quality, service levels, and productivity. Combined with process improvements, these can allow existing staff to handle a greater number (or higher complexity) of current projects, product releases, and units of work. Finally, semantic technologies can improve the Return on Investment (ROI) with the introduction of new capabilities that tap new sources of value, resulting in new advantages.

New life cycle economics

Semantic technologies improve economics and reduce risks across all stages (innovation stage, operations stage and maintenance stage) of the solution life cycle.

A semantic web approach has an important impact in the R&D phase considering that knowledge capture and modeling allows early validation and iterative refinement of requirements, minimizing cost and risk. Additionally, a semantic web approach impacts deployment and operations stage ROI turning it more interactive, incremental and flexible, resulting in lower exposure and faster time to value. Finally, a semantic web approach impacts maintenance and evolution stage ROI minimizing its cost and risk, considering that knowledge capture and modeling allows early validation and refining of requirements. At the same time, the use of semantic models and open standards insulate components to minimize impact of changes. This approach leads to best-of-breed substitutions, integration of new capabilities, and extension to embrace legacy applications. Enhancements happen faster and at lower switching costs.

MONETIZE WEB 3.0 VALUE CHAIN

Some business models appear from the potentialities of semantic web technologies and Web 3.0. These business models are based in a range of direct and indirect revenues as it is illustrated in Figure 1.

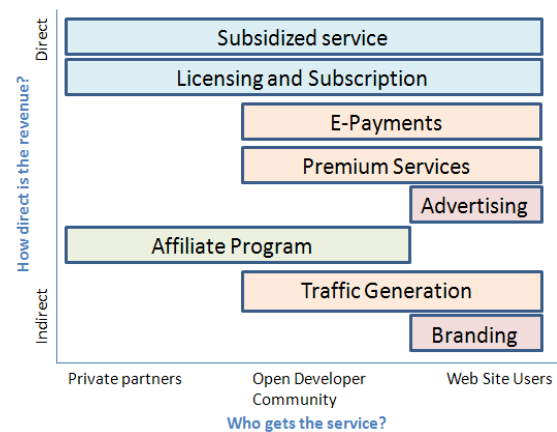


Figure 1: Web 3.0 business models

The business models presented in Figure 1 were adapted from business models for linked data and Web 3.0 initially proposed by Scott Brinker (Brinker, 2011). There are represented two dimensions in Figure 1. Along the X axis is represented who gets the service; along Y axis is represented how direct is the revenues.

In the following, we identified eight business models that offer a good representation of the different ways in which organizations can monetize, directly or indirectly, from Web 3.0 platforms.

Subsidized service

The subsidized model is at the top for two reasons. First, it is the most direct revenue source, because the government, an NGO, or regulatory paid to produce the service before it even has put online. Second, it emphasizes the distance between the subsidized model and the branded model.

The subsidized model makes the investment in some service or linked data because the delivery of such information is a core part of its organizational mission. In fact, it doesn't need to generate any subsequent financial return to the company. It is the model behind many of the largest linked data repositories on the web today, such as those from BBC or the US Census (Frost & Sullivan, 2009).

Typically the subsidized model appears when there is a need to provide a public benefit that could not be accomplished without a subsidy. It also can be considered a good beginning business project for a short term support that, in most cases, is necessary for the firm to become profitable. This strategy has some important drawbacks. One of them is the high level of dependence of a big customer (like it is the government); the other is the actual instability and recessions European financial situation that could decrease the interest of government agencies to participate in such initiatives.

Licensing and subscription

The licensing model is already very stable in the software industry (Rappa, 2004). The idea in the Web

3.0 environment is charge fees to let developers use data in other environments. In this way, the application and the use of the data inside the application domain is totally free of charge and only the data used outside the application has a cost for the developer.

This is a well known model that with web 3.0 will be improved as the data is easier for people to have new applications with newly combined data (Brinker, 2011). The buyers wish that their suppliers change their products or services to incorporate what they really need in particular. One of the ways to build demand is to modify our products and sell more to our current clients. One other way is offer and sell products that are modified for new types of clients (Kotler, 2009).

A variation of the licensing model is the inclusion of a subscription period. The subscription model charges for access to data for a period of time. Rather than sell the service directly, the promoter of the service is selling weekly, monthly or yearly access to the service or data contents. This, in effect, converts a one-time sale of a product into a recurring sale of a service.

The implementation of a subscription model requires the definition of the specific terms of use for the offered product or service and the limits of their usage. For instance, some subscription business models base their rates upon how often or for how long a customer uses the service. A good strategy is offer long-time memberships with lower prices, which will create sufficient capital up front that the company can use for financial investments and further research and development. Additionally, it would be interest to guarantee that the renewal process if effortless. This may involve automatic renewals, where the customer will be charged once the original term of usage expires unless the user specifically designates otherwise. Anyway, this can have potential legal issues in many countries and the company must be aware that many customers may find this unethical. Therefore, it is important to make it clear during the initial contract.

E-Payments

The idea is to get revenues from micro-payments for the individual use of data sets. These micro-payments can be easily deployed using electronic payments, namely using credit cards, e-checks, online bill pay and paypal.

Electronic payment is very convenient for consumers. Consumers can make e-payments at any time of the day or night, from just about anywhere in the world. At the same, it is a very fastest, simplest and safest way to perform a bill transaction. On the other side, electronic payments lower costs for businesses. The more payments they can process electronically, the less they spend on paper and postage. Offering electronic payment can also help business improve customer retention. A customer is more likely to return to the same Web 3.0 site where his or her information has already been entered and stored.

Table 2: Factors Discouraging Consumer for Online Payments (Sumanjeet, 2009)

<i>Factors</i>	<i>Percentage</i>
Concern about security	70
Difficulties to enter information	9
Do not have credit cards/smart cards etc.	7
Do not like interest charge	6
Purchase value too small	4
Exceeded personal limit	4

Table 2 shows some factors, which are obstacles in the online payment systems. Therefore, a good payment system should also consider these factors. The main concern in this model is the security offered to the consumer. This is a topic that has great relevance for the user. Secure transactions are the added value created by the company and offers recognition from the customers that, when satisfied, suggest it to others. The cost assuring a secure transaction exists and has to be planned. This model has no direct revenue but is one of the most important forms of obtaining a good image and reputation among the individuals.

The factors which are critical for the success of a e-payment system are multifaceted. These include integrity, non-repudiation, authentication, authorization, confidentiality and reliability, which are discussed below (Sumanjeet, 2009):

- Integrity – transaction data are transmitted and received unchanged and as intended;
- Non-repudiation – transactions have the quality of non deniable proof or receipts;
- Authentication – identities and attributes of parties engaged in transactions are established at some tolerate level of risk;
- Authorization: individuals are established and recognized as entitled to receive, send or view transactions;
- Confidentiality – transactions can be protected from view except by those who are authorized;
- Reliability – probability of failure in the send of transaction, receive or acknowledge is low.

Premium services

The idea behind this business model is to offer simple and basic services for free for the user to try and more advanced or additional features at a premium. For these companies, growth comes not only from new customers, but more often from existing ones. If clients are happy with the free portion of a service, they are substantially more likely to pay a small fee to get additional services. More importantly, they are the ones who evangelize a start-up business on social networks, as well as tout it to friends and family. Furthermore, the customers who trust the product so much they are willing to pay are even more inclined to refer to their friends and family.

The premium services are a complement to the free service that helps the company to be known to the consumer. This has to be developed to take full advantage of semantic web. The behavior of each user has to be the jumpstart for the companies offer. This can help the consumers choice because it's offered only what the user looks for.

This model allows the users to use a part of the product and interact in a way to create demand for other services or simple more added services provided at a established cost. This information can be obtained from the users in forms and forums at no cost.

There are some good examples of the success of this approach in the Web field. Flickr, a well known image and video hosting service began by offering a free service allowing users to upload pictures to share with friends. As demand for the service increased, Flickr began offering two types of account (free and subscription) providing unlimited bandwidth and storage for paying subscribers (Davis, 2010).

Advertising

At the present time, most social media services contain advertisements. Ads by Google are the most widespread and popular business model. The idea in the Web 3.0 world is to charge a small number of advertisers for brand visibility of sponsoring the data. Getting charges for ads placed around data on web pages can be an important source of revenue.

Essentially there are two approaches to implement an advertising promotion model in a Web 3.0 platform. Firstly is to see it as a web portal. Therefore, a high volume of user traffic makes advertising profitable and permits further diversification of site services. Secondly we can use some advanced business intelligence techniques as contextual advertising and behavioral marketing. Therefore, the ads are not static and can dynamically change due to the data content or the behavior of user in the Web 3.0 platform. As a consequence, contextual advertisers can sell targeted advertising based on an individual user's surfing activity.

Advertisement can gain a new life with this platform and consumers will have more choice in the offer they will receive. By receiving only the information that is relevant to the consumer it's more likely that he will pay more attention than when he is being overflowed with information that doesn't suits the consumer in question.

Depending in how significant the traffic is, advertising can have lower or higher costs or profits. The implementation of this model is made easier with the Web 3.0 platform by directing the adds to the users that really search for the product. This has lower costs and offers more efficiency.

Affiliate program

The idea behind this business model is provide data streams to affiliates who distribute them in other applications in exchange for commissions on related sales. Affiliates provide text and image ads to post on the publishers' sites. If a user clicks through to the affiliate site and takes a specified action (e.g., makes a purchase or fills out a registration form) the publisher is paid a portion of the revenue or a flat fee.

Affiliate programs are currently used by online marketers. They involve the marketing, promotion and selling of other businesses goods and services. Affiliates draw visitors to a web site or blog who are looking for information about a subject. They then supply information in the form of content and recommend products or services that the visitors may be interested in.

This model has been used by Amazon.com with well known benefits. The "pay-per-click" and "costs-per-click" are revenue forms that can be explored through this model. The cost implemented of this model can be easily covered by "clicks" revenue. Additionally, this model associated can be used with the traffic generation model to maximize it's revenues.

Traffic generation

The traffic generation business model is a good example of an indirect monetize source of revenue. The idea is very simple and consists in publishing data to earn favorable positions in search engines and other directories to generate more traffic. When the company gets more traffic, then there is a big chance to increase the revenues from other direct business models like m-payments, premium services or advertising.

Viral traffic is something that everybody would like to achieve but it's not as simple as it looks. The use of social network like Facebook or Twitter, the use of YouTube has to have a well established strategy. This strategy doesn't necessarily has costs. The ideas that have bloomed with this model have been simple. Having accomplished high traffic generation, a site can then use other model like advertising and the affiliate program more effectively. The feedback on this model actions is great in recognition, business offers and sales.

Branding

The rules of creation a brand since the introduction of Web 2.0 platforms changed totally the ability to harness and scale community. In many cases for consumers, participation in communities is not only effortless and pervasive but an expected part of the consumer experience. User-generated content was fundamental to growth in the Web 2.0 and, simultaneously, marketers have found that customer-developed content creates better products and services while building considerable buzz (OECD, 2007).

A well-developed brand community is an excellent tool for brand advocacy because community members feel strongly affiliation with the brand and the community. Communities allow companies and consumers to combine their efforts and create something larger than either could alone. When a community brings people together around something larger than the brand itself, the effects on consumers' perceptions of the brand can be significant. Additionally, communities increase the effectiveness and the efficiency of customer support.

Branding is focused on the brand itself and the other value of the product being embraced by the marketing concept embracing all possible marketing instruments. It can be developed in some sub-models like InBranding that includes brand alliance that can be beneficial to both partners.(e.g. GM and Northstar). This alliance has the objective of generating value. There is also Single-level Branding that is addressed to the next following stage in the value chain. Multi-level Branding is applied to all levels of the value chain.

The push and pull principle is the most basic ingredient of all this context. While Multi-level Branding uses it to pull the product through the distribution channel, Single-level uses it as a push-strategy to create more demand (Kotler, 2010).

Branding is can also create more traffic that can be used in association with the affiliate program. A well thought plan with various model implemented simultanely to branding can be a good source of revenues.

CONCLUSIONS AND FURTHER RESEARCH

The evolution to Web 3.0 will bring enriched capabilities for individuals to use and create content and it will provide enterprises with substantial and numerous opportunities to grow their businesses and improve efficiencies. Organizations need to be prepared for it by modernizing their infrastructure and business processes. A correct positioning of the company in the Web 3.0 world can be a distinctive success factor in the current competitive e-business market.

Semantic web technologies and Web 3.0 have brought new business models to the market. Some of them are based in direct or indirect revenues and have a different level of openness to the service. Good examples of direct revenue models are the subsidized, licensing or subscription. On the other side, typical indirect revenue sources include the using data to drive traffic to a web site or build one's brand reputation.

As future work it would be interested to identify some relevant international cases studies that already implement these Web 3.0 business strategies. Besides that, the notion of Web 3.0 can be a bit more inclusive. The appearance of new technologies and technologic concepts such as ubiquitous connectivity and intelligent applications (e.g., machine learning and autonomous agents) bring additional interactive features that are the bases of the idea around Web 4.0.

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PROJECT PORTFOLIO SELECTION AND MONITORING – A CASE STUDY

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ABSTRACT

Despite all the differences on markets, cultural environment, and organisational objectives, some changes are modifying the way business occurs, turning competitive advantages difficult to accomplish. In a global marketplace scenario, changes are constant and with variable amplitude. Organisations need to be alert to all movements to counter-answer and re-align themselves with the new market conditions. The organisational urge for using and applying new tools, methods and techniques is tremendous. However, there is no consensus about the type of method or technique that automatically improves any organisation, despite their own problems or status, restrictions and competitive advantages, strengths and weaknesses. Nevertheless, project management tries to see the organisation as a whole, and systematically challenge the difficulties encountered with new re-thinking processes in order to increase the organisational performance.

So it is of great importance to develop a flexible and expandable decision support system, which considers several different criteria, methods and phases in the most suitable way for the PPM, involving the full participation of the decision-makers and providing the users with a quick feedback impact, in certain parameters, of the consequences of the changes produced.

INTRODUCTION

Project management has been, over time, an area with tremendous growth and prominence within organisations. However, it presents problems and difficulties that require a careful analysis to tackle the complexities and peculiarities that commonly are associated with it (Yeo, K.T., 1993; Shou, Y. and Huang, 2010). Organisations continue to face tremendous difficulties in meeting schedule and cost estimates. According to the 10th edition of the CHAOS report of

Standish Group, almost 51% of all projects in the survey fail in attaining the cost and schedule estimates and functionality requirements (Henry et al., 2007).

Cooke Davies, T. (2002) and Pheng and Chuan (2006) pointed that despite of several past studies carried out to assess the key factors that contribute to project success, those factors are not sufficient to foresee it, to the extent that projects are developed in a dynamic environment and can be positively and/or negatively influenced by a multiple nature of factors, which might limit their overall performance. As an example, the project manager leadership style (Turner and Muller, 2005), the relationship with the project team members (Mota, C. et al., 2009) and the managerial practices used (Hua Chen and Tau Lee, 2007) seem to be directly related to the project performance.

Today's business environment is extremely complex and dynamic which requires making faster decisions, better allocation of the organisational scarce resources, and a clearer strategic focus (Elonen, S. and Artto, K., 2003). Despite all the differences on markets, cultural environment, and organisational objectives, some changes are modifying the way business occurs, turning competitive advantages difficult to accomplish. In a global marketplace scenario, changes are constant and with variable amplitude. Organisations need to be alert to all movements to counter-answer and re-align themselves with the new market conditions (Amaral, A. and Araújo, M., 2009a).

Organisations are dealing, each time with more and more projects in their daily routines. According to Maylor, H. et al (2006, p.663): "Nowadays, it is hard to imagine an organisation that is not engaged in some kind of project activity. Over the past decade, organisations have been turning from operations to project management as part of their competitive advantage strategy".

Managers, face an utmost challenge of selecting the proper projects to the portfolio, pondering which projects have the greatest potential to create value to the organisation (M. Menke, 1991; Chu, P.-Y. V. et al.,

1996). Part of this challenge is divided in tackling the “right projects” and the other in “doing projects right”.

Project Portfolio Management (PPM) seeks to improve organisational performance and efficiency (Ireland LR, 1997), to coordinate interrelated projects and diminish project cycle time (PMI, 2005), as well as acquire and develop learning mechanisms to outperform the competition. The PPM processes must include the project alignment with the business strategy, the selection of the proper projects, the allocation and balancing of the organisational resources and the periodical reassessment of the mix of projects, to check whether the selection is still aligned with the main business goals (Kremmel, T. et al., 2011; Reyck, B. D. et al., 2005; Amaral et al., 2010a).

This work aims to highlight the peculiarities of each of the PPM phases, pointing our approach towards the resolution and the integration of such phases. The example presented uses real world business data, from an I.T. enterprise, which allowed us to apply the techniques and test our PPM framework. Despite of being a microenterprise, with limited resources, we were able to test it at the extent needed. However, the research time restriction and the multitude of the projects considered, with different project life cycles, prevented us to fulfill all phases. The monitoring and control phase, the learning opportunities gathering possibility during the project implementation, and the resource scheduling heuristic approach were not fully tested because the IT enterprise has few resources available and with no redundancy of skills and competencies, therefore each resource is somehow exclusive. In the early steps of this work, it was very important, to explain the purposes and fundamental concepts related to the PPM. The enterprise didn't have any defined methodology for managing the projects portfolio, as well as, any process to properly assess the projects and overcome the uppermost challenges related to the market dynamic, strategy alignment, project pre-screening, portfolio selection, resource scheduling, monitoring and control and learning mechanisms. We believe that the reality of this enterprise was not different from the vast majority of the micro, small and medium enterprises that commonly use ad-hoc approaches to manage their projects.

The remaining of the paper is organised as follows. We will focus on the PPM phases, presenting some literature that support our PPM framework. Then we will present our alignment technique and the DEA approach used in a I.T. organisation, for selecting the projects portfolio. Afterwards, the main results, conclusions and further developments.

BACKGROUND

Project Alignment

Successful organisations developed, during time, a conscious strategy and established a closer relationship with the market. The strategic plan development tries to project the organisation into future scenario(s), defining concrete actions for attaining the organisational objectives. So, reaching these purposes requires ability to measure the market oscillations, analysing the critical information obtained, readjusting the strategic plan with the lessons learned and conferring it some flexibility to be able to rapidly respond to the market (NadKarni, S. and Narayanan, V.K., 2006)

Projects and project management serve as primary capabilities of an organisation to respond to change and thereby maintain a competitive edge (Turner, 1999). Projects may be considered as building blocks in the design and execution of future strategies of the organisation. Several authors have emphasized the importance of linking projects and their management to strategy and proposed different models describing how the management processes at project and multi-project levels can be integrated with the organisational strategy management process (Cooper, et al., 1997; Englund and Granham, 1999).

In addition, the linkage between strategy process and project management, as well as the availability of high-quality information are identified as success factors (Carazo, A.F. et al, 2010).

Project Portfolio Selection

The Portfolio selection involves a comparison of projects, which compete between each other. There are numerous portfolio selection techniques that can be used to carry out the desired portfolio selection. Some of them will be briefly mentioned: a) Ad hoc approaches; b) Comparative approaches including Q-Sort (Sunder, 1984), pair wise comparison (Martino, 1995), the Analytic Hierarchy Procedure (AHP) (Saaty, T.L. et al., 1980; Dey and Gupta, 2001); c) Scoring models (Martino, 1995); d) Portfolio matrices (Max and Majluf, 1996) generally used as strategic decision making tools, and also to allocate resources among competing projects; e) and Optimization models (Abdelaziz, F.B. et al., 2007; Doerner, K.F et al., 2006; Kavadias and Loch, 2003), fuzzy and artificial intelligence algorithms (Lin and Hsieh, 2004) which are generally based on some form of mathematical programming, to support the optimization process and to include project interactions such as resource dependencies and constraints. Coffin and Taylor (1996) used fuzzy theory for the project selection process. Ghasemzadeh and Archer (2000) presented a 0–1 integer linear programming model for selecting and scheduling an optimal project portfolio. Cooper, W.W. et al. (2004) presented several examples of applications of the DEA in multiple situations and

different activity sectors like: banking, hospitals, universities, police, telecommunications, army, etc.

Project Scheduling

Project Scheduling (PS) is a typical problem of Resource-Constrained Project Scheduling Problem (RCPPSP). Known as being a NP-hard problem, RCPSP is a generalization of the Job Shop Scheduling Problem (JSSP) which has been studied with a wide range of models, applications, and algorithms. Considering that several projects are simultaneously competing for scarce resources like in the Portfolio case, the scheduling problem turns into a Resource Constrained Multi-Project Scheduling Problem (RCMPSP) (Kao, H.P., 2006).

Project Portfolio Scheduling (PPS) is a difficult problem to solve because it inevitably involves uncertainty. The most well-known technique used in practice to PPS is the Critical Path Method (CPM), although this technique is merely deterministic, which means that uncertainty is not considered in the task definition. PERT, another well-known technique (Miller, R.W. 1962), uses three different estimates (pessimistic, optimistic, and most likely), instead of having a single deterministic value. Other common technique used is the Monte Carlo simulation (MCS) that was implemented in the 1980s (Fishman, G.S., 1986), despite of having already been applied to project scheduling in the 1960s.

The exact methods are other common approaches used for the PPS problem (Chen, V.Y.X. 1994) despite of being limited to solving small problem instances and impractical for solving large RCMPSPs (Herroelen, W. and Leus, R. 2005). Hence, Priority Rule (PR) based heuristics are widely adopted for the RCMPSP although their performance is not totally guaranteed. These heuristics are fast and can be easily integrated into project portfolio selection and scheduling algorithms (Gutjahr, W.J. et al., 2008). Priority rule (PR) heuristics are necessary for solving very large problems, and are extensively used by commercial projects scheduling software due to their speed and simplicity (Herroelen, W. and Leus, R. 2005). Some examples of Activity-related PRs assign high priority to an activity based on a parameter or characteristic of the activity itself, such as its duration (e.g., shortest operation first—SOF) or slack (e.g., minimum slack first—MINSLK).

Our PPS approach encourages the use of the work developed in PRs by Browning and Yassine (2010).

Monitoring and Control

The Earned Value Method (EVM) is a multidimensional project control method that integrates cost, schedule, technical performance, and scope. Various forms of EVM have been in use since the industrial revolution when managers started looking for ways to measure the performance of manufacturing processes, like Fredrick

W. Taylor, Henry L. Gantt, and others in late 19th century. By comparing planned standards with earned standards and measuring actual expenses, they could identify cost variance as the difference between the actual costs of performing work, and value of the achievements according to their estimated or budgeted costs.

The Project Management Institute defines earned value management (EVM) as —a management methodology for integrating scope, schedule, and resources, and for objectively measuring project performance and progress. Performance is measured by determining the budgeted cost of the work performed (i.e. earned value) and comparing it to the actual cost of the work performed (i.e. actual cost). There is consensus between the Project Management Institute (PMI) and the International Project Management Association (IPMA) in recommending the utilization of the EVM.

PROJECT PORTFOLIO MANAGEMENT (PPM) FRAMEWORK

According to the authors' view, tailored by the literature review, the project portfolio selection normally, involves five distinctive phases:

a) the strategic consideration and orientation, towards the definition of the organisational strategy. For this phase we developed a market attractiveness technique (Amaral, A. and Araújo, M., 2009a);

b) the *project pre-evaluation phase*, where the benefits derived through the evaluation methods are to be determined, as well as the individual contribution of each project to the portfolio objectives. This intends to eliminate any non-starters projects, which do not have conditions to integrate the portfolio and also to reduce the number of projects to be considered simultaneously. The stopping criterion should be adjusted to the amount of projects that need to be considered, because according to Archer and Ghasemzadeh (2009, p.209): "...the complexity of the decision process and the amount of time required to choose the portfolio increases geometrically with the number of projects to be considered". In this phase we used the project alignment technique (Amaral, A. and Araújo, M., 2009b), that will be explained and treated in more detail in the following Section;

c) the *project evaluation and selection*, involves a continuous comparison of competing projects, with the objective of ranking in the top positions to achieve the entrance to the organisational portfolio. For this purpose we applied the DEA approach using 10 indicators, described later (Amaral, A. and Araújo, M., 2010b).

The evaluation period should be determined when new projects are being considered for selection, or when the portfolio premises are altered, and the organisational

context, internally or externally, obliges to re-assess the current portfolio projects, and possibly doing some adjustments;

d) After prioritising the projects to the Portfolio it is essential to schedule the organisational resources. The organisational assets are limited and constantly requested for different projects, which can cause an extremely complex managerial problem. We favour the utilization of the Priority Rules Heuristic, proposed by (Browning and Yassine, 2010) despite of not using them in this present work;

e) and the monitoring and control phase, which is responsible for assessing, recurrently, the portfolio performance and all that is related to the portfolio range. This phase is very important from the managerial point of view, since it can contribute to the creation of a learning mechanism that sustains the organisational knowledge, and therefore potentiates an increased organisational overall performance. Projects portfolio plays an important role in achieving the learning that takes place within many organisations (Keegan and Turner, 2001).

Organisations also acquire new knowledge through experience (Huber, 1991) or learning by doing. Through trial and error experimentation, organisations can learn about new approaches to accomplish the work at hand (Garvin, 1993). An organisation can also learn from feedback on the consequences of its actions, learning about projects by feedback and experience, developing project work, and transferring the lessons learned to other projects (Suikki, et al., 2006). So, it is very important to be prepared for these new challenges and differentiation paradigms. With the proper organisational maturity and sustainability culture it will be possible to attain higher levels of efficiency, performance and of sustainable growth in the organisation.

This phase could no be applied in the case study because all the projects considered in the portfolio were in their early stages. Despite that the organisation will be willing to do it for properly managing the running projects, in order to be able to gather the learning possibilities derived from their managing process of the projects portfolio.

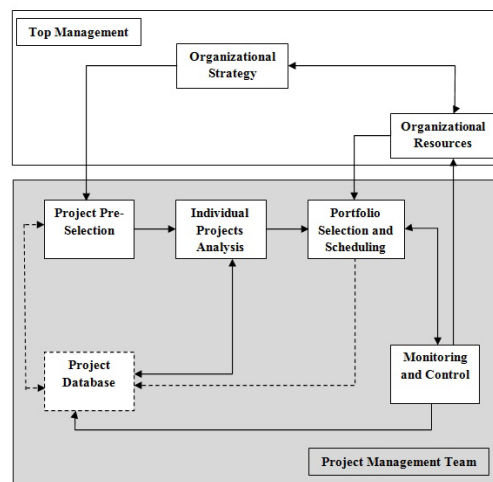


Figure 1 - PPM Framework

CASE STUDY – EXAMPLE

Project Alignment Technique

The project alignment index calculation phase intends to quantify the data collected from 5 indicators, in order to determine an index for each project in the pre-selection process. The top management, according to the strategic definition of the organisation and the weighting of the minimum values of attractiveness for each of the indicators, will contribute to the allocation of the projects by defining a cutting area in which each project must be selected. This technique is divided in three main steps, which consist of:

- 1) set the minimum values of attractiveness by indicator;
- 2) calculate the alignment index by project; and finally

- 3) select the projects that fulfill the minimum attractiveness value for the alignment index.

Variables:

M = Number of indicators: {1,..., 5}

Ω = Project Alignment Index

P = Indicator values: {1,..., 5}

Q = Weighting values: {1,..., 5}

Parameters:

K = Number of projects in assessment: {1,..., 8}

The five indicators proposed come from different elements whose combination produces information considered critical to guarantee the project alignment with the organisational strategy.

M1 = Degree of Innovation Expected - The degree of innovation expected varies between 0 and 100, and quantifies the level of impact that each project may have on the technological structure, and its level of attractiveness in emerging markets that can enhance organisational performance;

M2 = Risk Perception - The risk perception is quantified by the decision agents and varies between 0 and 100, being 0 the absence of risk and 100 corresponding to the most complex and sensitive environments in which the degree of volatility is very high;

M3 = ROI - This indicator reflects the return on investment (ROI). Despite of the literature indication that the selection of projects should not only rely on economic and financial indicators, it is of common and mandatory use. Projects must have this type of information available. This indicator is usually presented in monetary values or percentage;

M4 = Total Resources Needed / Total Resources available. This indicator considers the number of resources needed by project, and also foresees some future problems of allocation and balancing of resources that may exist at later stages, as well as the risk of concentrating in one project several key organisational resources;

M5 = Project Schedule / Market clockspeed. This indicator shows the degree of anticipation that the organisation has towards the market clockspeed. The numerator and denominator should be measured on a time scale, preferably in months or years. This indicator should be, in ideal situations, less than 1, presenting the ability of innovation and flexibility of the organisation.

It can be translated into increased performance and into achievement of sustainable competitive advantages.

Data and formula calculation

The final purpose of this approach is to discover, according to the evaluation and the classification of the different decision makers for each indicator, what is the list of markets that best suits the organisational profile, and thus where should the organisation focus and investment be directed.

Before the individual calculation of the project alignment index, the decision team establishes its value of reference, which reflects the minimum values of attractiveness for the different indicators as well as the weight for each one. (See Figure 2)

	Indicators	Reference Values (P)	Weight (Q)
M1	Degree of innovation expected	40%	0,40
M2	Risk perception	75%	0,30
M3	Net Income expected	20,00%	0,80
	Investment projected		
M4	Total workforce needed	40%	0,70
	Total resources available		
M5	Project Schedule	1	0,60
	Market Clockspeed		
		0,82	

Figure 2 – Organisational reference Values (P) and Weights (Q) by Indicator

The proposed simple calculation of the project alignment index is presented in Equation (1).

The data from the 8 projects is shown in Table 1, where the alignment indexes of each project are calculated in this pre-evaluation phase. The alignment index calculation favours the maximization of M1 and M3 indicators, and the minimization of the M2, M4 and M5, as we can see in the Equation (1). The minimum value considered for project alignment is **0,82**, as mentioned in Figure 2.

$$\Omega_k = P_1 * Q_1 + (1 - P_2) * Q_2 + P_3 * Q_3 + (1 - P_4) * Q_4 + (1 - P_5) * Q_5 \quad (1)$$

Table 1 - Project Alignment Indexes Calculation

	P1	P2	P3	P4	P5	P6	P7	P8
M1	0,70	0,20	0,30	0,50	0,45	0,30	0,40	0,10
M2	0,50	0,85	0,40	0,50	0,20	0,40	0,50	0,40
M3	0,67	0,25	0,10	0,55	-0,05	-0,10	-0,20	0,15
M4	0,30	0,13	0,25	0,13	0,40	0,45	0,40	0,63
M5	0,69	0,20	0,17	0,27	0,17	0,60	0,34	0,90
Ω_k	1,64	1,42	1,40	1,84	1,30	0,85	0,96	0,66

The data presented shows that all the projects except project 8 obtained higher indexes compared to the

minimal attractiveness index defined by the organisation. The data marked in red highlights values

which are in disagreement with the policy defined by the organisation. For example project 2 presents values which cause some consideration, like a low degree of innovation (M1=0.2) and higher level of risk (M2=85). The predefined values of Figure 2, if too restrictive, can lead to an empty portfolio. Decision makers will have to ponder those situations, and slack them if needed. In this case study, only projects 1 and 4 respect all the conditions required. It is also important to mention that Projects 6 and 7 present values near the minimum acceptable.

DEA Approach

Data Envelopment Analysis (DEA), a non-parametric linear programming method, was used to assess the projects' indicators and choose the proper ones to the portfolio based on their performance. DEA was introduced by Charnes et al. (1978) and it is a fractional programming model that estimates the relative efficiencies of a homogeneous set of units by considering multiple sets of inputs and outputs. According to Charnes et al. (1978), DEA has the following advantages in assessing project productivity: a) It does not require functional relationships between inputs and outputs; b) Multiple inputs and outputs can be considered concurrently; c) It has the ability to identify inefficient projects; and d) Using DEA sensitivity analysis, the sources and amounts of inefficiency for each inefficient project can be found.

A conventional single performance criterion, whether it measures profitability, strategic focus, project value added, is clearly insufficient to determine the excellence of an enterprise. Consequently, a number of studies suggested that a multi-factor performance measurement model should be used to characterize it (Chin et al., 2003). Data envelopment analysis (DEA) uses a mathematical programming model to estimate best-practice frontiers without a priori underlying functional form assumption through computing multi-input/multi-output values (Guan and Ma, 2003). The major advantage of the DEA approach is not to require any assumptions about the mathematical function form. That means that DEA does not need any prior information on the underlying functional forms and weights among various input and output factors. Thus, DEA is

particularly suitable for analyzing multiple inputs and multiple outputs production systems (Charnes et al., 1985; Zhu, 2002).

Inputs and Outputs

To apply the DEA, we began by defining a group of indicators. The indicators proposed came from different elements whose combination produces information considered critical to guarantee the project alignment, the economical, financial and operational assessment of the project towards selecting the proper portfolio. The indicators used are the following, additional to the ones presented in the alignment technique:

KPI4 = Net Present Value (NPV) – This indicator determines the present value of the project's cash flows at a given interest rate.

KPI5 = Internal Return Rate (IRR) - This indicator represents the maximum return rate of the project, which means that it is the discounted rate that, for the whole project's lifetime, turns the NPV equal to zero.

KPI6 = Cost / Benefit ratio - The cost benefit analysis lists project revenues with the expenses in terms of ratio. It is a crude indicator, it does not take into account the time when the expenses or revenues occur, but it is usually appreciated by companies. A project is considered profitable when the cost / benefit ratio <1, i.e. when the benefits outweighs the costs. An investment project is all the more interesting the lower the cost/benefit ratio..

KPI7 = Gross Value Added (GVA) - A productivity metric that measures the difference between output and intermediate consumption. Gross value added provides a quantity of money for the amount of goods and services that have been produced, less the cost of all inputs and raw materials that are directly attributable to that production.

KPI9 = Critical Path Method (CPM) – It is a technique widely used for determining the optimum duration and sequence of the network activities of a project which includes a list of all activities required to complete the project, the time (duration) that each activity will take to completion, and the dependencies between the activities

	%	%	%	€	%	%	€	%	Months	%
	(-) KPI 1	(-) KPI 2	(+) KPI 3	(+) KPI 4	(+) KPI 5	(-) KPI 6	(+) KPI 7	(-) KPI 8	(-) KPI 9	(+) KPI 10
Projects	Project Schedule	Nr. Resources Needed	ROI	NPV	IRR	Cost/Benefit Ratio	Gross Value Added	Risk Perception	CPM	Degree of Innovation Expected
	Market Clockspeed	Total Nr. Resources								
P1	68,7%	30,0%	67,0%	22.605,01 €	65,71%	28,55%	33.790,00 €	50,0%	6,87	70,0%
P2	20,0%	12,5%	25,0%	1.448,99 €	20,23%	8,97%	3.440,00 €	85,0%	2	20,0%
P3	17,0%	25,0%	10,0%	- 269,02 €	-4,37%	63,17%	1.750,00 €	40,0%	1,7	30,0%
P4	27,3%	12,5%	55,0%	1.120,04 €	16,53%	35,11%	3.092,25 €	50,0%	2,73	50,0%
P5	17,0%	40,0%	-5,0%	- 1.114,67 €	-33,32%	187,91%	705,00 €	20,0%	1,70	45,0%
P6	60,0%	45,0%	-10,0%	- 3.769,14 €	-23,16%	283,05%	1.050,00 €	40,0%	6,00	30,0%
P7	34,3%	40,0%	-20,0%	- 3.088,61 €	-42,27%	326,91%	800,00 €	50,0%	2,43	40,0%

Figure 3 - KPI's input data for DEA

Table 2 - DEA Output

Projects	Effencies Input/Output Radial Model
1	100.00
2	100.00
3	88.54
4	100.00
5	100.00
6	43.64
7	70.35

The Projects that achieved 100 are the ones who reached the maximum level of efficiency. Those are the ones that should be considered for the project portfolio selection. Projects which are not efficient can be adjusted based on assessing the data provided by the DEA output pointing which indicators must be improved in order to reach the desired efficiency level. Therefore, it shows the potential for future reassessment – where projects can be improved (See Figure 4).

Table of peer units				
Peers for Unit PROJECT06 efficiency		43.64%	radial	
PROJECT06		PROJECT01	PROJECT05	
ACTUAL	LAMBDA	0.304	0.456	
60.0 -KPI1		21.0	7.7	
45.0 -KPI2		9.1	18.2	
283.1 -KPI6		8.7	85.6	
40.0 -KPI8		15.2	9.1	
6.0 -KPI9		2.1	0.8	
-10.0 +KPI3		20.4	-2.3	
-3769.1 +KPI4		6867.3	-508.1	
-23.2 +KPI5		20.0	-15.2	
1050.0 +KPI7		10265.3	321.3	
30.0 +KPI10		21.3	20.5	
Peers for Unit PROJECT07 efficiency		70.35%	radial	
PROJECT07		PROJECT04	PROJECT05	
ACTUAL	LAMBDA	0.277	0.736	
34.0 -KPI1		7.5	12.5	
40.0 -KPI2		3.6	29.4	
326.9 -KPI6		9.7	138.3	
50.0 -KPI8		13.8	14.7	
2.4 -KPI9		0.8	1.3	
-20.0 +KPI3		15.2	-3.7	
-3088.6 +KPI4		310.1	-820.6	
-42.3 +KPI5		4.6	-24.5	
800.0 +KPI7		856.2	518.8	
40.0 +KPI10		13.8	33.1	
Peers for Unit PROJECT03 efficiency		88.54%	radial	
PROJECT03		PROJECT01	PROJECT05	
ACTUAL	LAMBDA	0.013	0.404	0.239
17.0 -KPI1		0.9	10.9	4.1
25.0 -KPI2		0.4	5.2	9.5
63.2 -KPI6		0.4	14.2	44.8
40.0 -KPI8		0.7	20.2	4.8
1.7 -KPI9		0.1	1.1	0.4
10.0 +KPI3		0.9	22.2	-1.2
-269.0 +KPI4		294.7	451.9	-266.0
-4.4 +KPI5		0.9	6.7	-7.9
1750.0 +KPI7		440.5	1247.7	168.2
30.0 +KPI10		0.9	20.2	10.7

Figure 4 - DEA sensitivity analysis to inefficient projects

The Project Portofolio Scheduling phase is not considered in this case study, mainly because the amount of resources needed for the projects selected to the portfolio are less then the amount of resources available for starting all projects simultaneously (as we can see in Figure 3, by adding the values of KPI2 of the different projects selected to portfolio we obtain 95% of total resources). In the present macro-economic scenario that the companies face, with the generalized crisis situation, the organisation is focused in attaining the maximum number of projects possible. The monitoring and control phase was not developed also, because all

the projects considered were start-up projects which have been presently adjudicated and are currently in their beginning phase.

CONCLUSIONS AND FURTHER RESEARCH

The project management literature is rich in presenting several techniques and methods for the selection of projects portfolio. However, despite of numerous examples found, these do not solve the problems of simultaneously treating strategic alignment of projects and weighting of generic metrics, in order to improve the projects portfolio selection process. Thus, this paper presents an innovative approach for selecting the portfolio of projects by using DEA, and the development of a group of generic indicators, to support the decision makers in considering multiple projects.

Each decision maker can use all or some of the indicators proposed, thus each ones participation, knowledge, sensitivity and intuition are taken into account, namely for indicators such as risk perception, level of innovation, market clock speed, project's complexity. This is also considered a critical factor for the successful implementation of a technique, which is, achieving the involvement of top management. It is easier when they fully understand the method and actively participate in the decision process.

The development of the indicators proposed is not a closed process. According to the business area and the projects' unique characteristics it might be necessary to introduce new metrics. However, we believe that the indicators presented are a good starting point and are generic enough to be able to be applied in any business area. The case study developed gave us an overall view of PPM, and enabled us to combine all the techniques, to gain important feedback from the staff during the time spent in the organisation, and to test our developments with real word business data. Our ambition, as a future development, is to test our PPM framework in other business areas, and essencially in larger organisations with other complexities and challenges that would allow us to gain other views.

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TECHNOLOGICAL EXTENSION PROGRAM PILOT PROJECT IMPLEMENTED IN THE CAPITAL GOODS SECTOR IN SÃO PAULO - BRAZIL: PROMOTING TECHNOLOGICAL INNOVATION

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Technological innovation, Technological extension, SMEs, capital goods sector, Brazil

ABSTRACT

Technological extension is recognized by the Organisation for Economic Co-operation and Development (2005, OECD) as fundamental for economic development, by promoting and stimulating further technological innovation, especially in small and medium-sized enterprises (SMEs). Despite its importance, particularly with respect to the impact of public or private initiatives that promote technological extension within the SMEs, the technical literature is not abundant on this subject and just a few case studies can be found. Moreover, development of structured extension programs based on the transposition of experiences between countries is very complex, mainly due to the diversity of economic, cultural, political and technological realities. Another important challenge is related to the concept and the structural base of the technological extension. This paper is written using the methodological reference and systematization of information available in the bibliography from the OECD. Based on this reference, the Ministry of Science and Technology of Brazil started four pilot projects to be implemented in São Paulo, Paraná, Santa Catarina and Bahia. These projects had two main objectives of putting in practice the technological extension service and analyzing its impact on firms. This article presents the process of implementation of the pilot in São Paulo. In this project, fifty firms of the capital goods sector were investigated. The results were the following: many firms showed improvement in the management of the production flow, a more consistent planning, a better control of many phases in the activity of the firm and increases in productivity. Based on these results, it can be concluded that the pilot program's technological extension proved to be relevant to SMEs due to specific management actions focused on the real needs of each firm, combined with the technological support provided and the low financial investment made by firms. Since this is a new and unknown project to most firms, many businessmen manifested doubts and uncertainty concerning the program. In this sense, after the

evaluation of the whole process of implementing the pilot project, it was suggested to extend the same project to economic sectors in São Paulo. With this enlargement, it is intended to achieve a better promotion and publicity as well as adopting the concept of the technological extension. The program became effective as a part of the Science, Technology and Innovation Program promoted by the Brazilian government.

INTRODUCTION

This article aims to present the experience of a pilot project on technological extension in the state of São Paulo, Brazil. It also proposes to show the relationship between the concept of technological extension and the applied technological innovation within SMEs, pointing out strategies and appropriate tools to achieve this demand.

For these purposes, the first section of this paper shows the importance of SMEs for one country's economy, providing a brief history of the SMEs in Brazil, and it continues by discussing the relevance of the introduction of technological innovation within SMEs and the its wealth creation impact. In the second section, it is presented a brief discussion about the diffusion of technology in OECD countries, as well as the collaboration from Brazil on the governmental initiatives related to the main subject. The concept of technological extension is presented as a tool to extend the diffusion of technology to support SMEs. The section concludes showing a framework of the capital goods sector and its importance to industry. In the following sections it is included the methodology and results. Finally, some considerations were made in the concluding section.

THE ECONOMIC IMPORTANCE OF SMEs AND TECHNOLOGY

The importance of the small and medium-sized enterprises (SMEs)

The main role of a big company concerning the economic context of a country is largely understood and respected. Although there are some studies (Audretsch, 2004) that focuses on the increasing importance of the

impact from SMEs in the economy, particularly in their participation/collaboration in industrial production and their capacity of creating employment and wealth.

In 2001, in Brazil, according to the data from RAIS - MTE (in SEBRAE, 2003) the number of companies was 5,57 million, 99,6% of which were SMEs. In these companies there were 14,6 million of employees.

In the industrial sector there is also a big number of SMEs, in real numbers they are 987 thousand. That means that 5,01 million of people are employed in those companies. The micro and small-sized enterprises were responsible of 28% of production, and the other medium and big companies were responsible of 72% of production (SEBRAE, 2003).

In the year 2000, concerning export data, 63,7% of exports, in value, were from micro and small enterprises, the medium sized enterprises exported 19,6% and the big sized enterprises exported 6,9%.

The international report from Global Entrepreneurship Monitor (GEM, 2004), emphasises the importance of SMEs in the economical context of Brazil, reinforcing the existence and strength of policies, and technological developing programs, that stimulate entrepreneurship, particularly those dealing with:

1. The strenghtness of a global market structure;
2. The technical training of intreprenurship;
3. The existence of conditions that enables firms to have a better market efficiency, global capacities, technonological transaction data and export market.

It is worth to refer that most of the topics above are suggested to be implemented in countries with low wages and low technological development. Although the above mentioned bibliographies refer all the important data, there is a low performance of SMEs concerning the technological dimension, which will be referred in the next chapter.

Technological innovation and SMEs

In OECD (2005), the importance of using science, technology and innovation to achieve economic and social goals is stressed. This environment has been heavily influenced by the increasing competitiveness of all country members from OECD. It also incentivates the creation, diffusion and exploitation of scientific and technological knowledge, as well as other intellectual goods, in the way of improving development and productivity.

The relation between technological innovation and economic development is largely recognized and accepted. Technological innovation should lead a firm to competitive advantages, either by reducing costs through a new production process, or through logistics simplification processes (Porter, 1990), or by differentiation, development of new products and improvement of already existent products, concerning their specifications, quality or flexibility.

To stimulate the theme discussion about technonolgy it is necessary to deal with the term “technological innovation” and its results. There are two possible references that are used in this paper. The first is the Survey of Technological Innovation - PINTEC (IBGE-Braslian Institute of National Statistics and Geography, 2000). This reference works with the subject according to the orientation of the Frascati's and Oslo's Manuals, both published by the OECD. These manuals are used by each country member from OECD as a reference to collecting statistic data in the area of science and technology. The second reference is the National Quality Foudation (FNQ), that works with other orientations related to National Quality Awards in other countries.

Technological innovation is defined in PINTEC (2000) as: “the implementation of technologically improved products (goods or services) or processes or new products”. Meanwhile the definition of marginal and substantial changes is established by each firm. Different types of innovation might occur simultanally or in an independent way, that means, a product innovation may be created, and its production could be made in a conventional way regarding technology, or it may require a process innovation.

According to the FNQ innovation is considered as “the promotion of big changes that lead to improve the process and products in the organization and the creation of additional in value for both parts”. Both concepts have in common the idea of improving product and process, however it is also important to gather some value to both parts. To be considered innovation it is not enough to improve the process/product. An innovation should obtain a result after its implementation, that means it must be considered from the efficiency perspective. To set some value it is necessary to reduce losses during the productive process, to reduce activities that do not bring new value and to improve the material and information flux.

The concepts used by PINTEC argue that the innovative activities and the implementation of technological innovation might be developed within the firm or through the acquisition of goods, services and external knowledge. The firm that develops internally innovation makes it through activities of R&D, that may be in a continuous or ocasional way. It mayalso be formal, when there is a formal structure within the organization of the firm; or informal when it does not occur within a formal structure, i.e, staff and materials used in other functions are also used to those activities.

Asides from R&D, there are firms that implement several innovative activities trough the incorporation of new technologies, for instance, the acquisition of technology introduced in machinery and equipments technologically more advanced than those used; the acquisition of external knowledge (know how); external R&D (firms or laboraties to execute R&D activities which the firm cannot execute); training; marketing and advertising, market research and industrial structural

changes that allow the registration of the final product/label.

- Concerning the above mentioned activities, some data from PINTEC (IBGE, 2000) show that, considering 72 thousand industrial firms with 10 or more employees, 22,7 thousand of firms (31,5%) had implemented innovations actions, with an investment of R\$ 22,35 billion, the equivalent to 3,8% of its cash flow. See table 1, in annex.

Considering Table 1 and the total of investment in innovation, we see that 52% were destined to the acquisition of goods, which agrees with the above mentioned references opinions. However, large firms (with more than 500 employees) are at the front line with 68,4%, and meanwhile the same index falls down to 31,6% considering firms between 10 to 49 employees.

Considering the big number of micro, small and medium-sized enterprises, those correspond to more than 4,55 million of firms and more than 8,57 million of employees. This group of firms has an high impact. It might be important to elaborate on the possible competitiveness impacts on those firms..

There are different competitiveness levels within SMEs, that could be better understood if four relevant aspects are considered:

1. Big firms have more R&D investment capacity and because of that more capacity to innovate. Another competitive advantage is related to easier and larger access to consumers markets, since they already have strong and solid structures with distribution channels and publicity investment;
2. Capacity to create employment: the big companies although being small in number, employ 56% of all employees, while the medium-sized enterprises employ 16%, and the other employees are employed by micro and small firms. In addition to that, the big firms tend to offer better work conditions and better salaries;
3. Capacity to export: it requires a certain articulation level, capacity to negotiate in international markets, the power to negotiate prices, organized actions, appropriate products and process which respect the international standards. The SMEs have "natural defects" related to how to learn to plan high impact strategic actions with longer timetables, managers limited technical capacity and low resources to invest in the export market;
4. A "natural facility" dealing with governmental credit lines for any purpose (export, production growth, R&D), particularly the availability to real guarantees, for instance, low taxes, nonrefundable. The above mentioned does not happen within SMEs.

In any case the improvement of competitiveness within SMEs could only be achieved with the improvement of internal systemic factors. In this context, technological management is brought up, herewith recognized as a sequence of necessary actions to identify, analyse, develop and test products before being in the production process, as well as process and services originated from business opportunities observed in a competitive environment (OECD, 1997).

DIFFUSION OF TECHNOLOGY AND RELATED PROGRAMMES

Technological diffusion in countries members from OECD and Brasil

According to OECD (1997) governmental initiatives should promote technological diffusion. Many studies on the technological effect in the productivity of industrial firms reveal that there is a big dependence on technologies developed in other place and not developed in the own company.

In this sense, the analysis of several governmental actions indicates that there is a kind of technological diffusion programs typologies, which have being constructed according to their aims, operational focus (previous demand) or specific group action. In general, these diffusion programs typologies act within the firms at three levels:

1. Programs that improve the absorption and adaptation of specific technologies;
2. Programs that improve the capacity of firms which receive technologies to be used in general terms (technical assistance projects, and information networks);
3. Programs that build the whole capacity of innovation within the firms, including the use of tools as sectorial maps, diagnoses and benchmarking. The OECD (1997, pg.09) suggests four categories of technological diffusion programs based on their operational focuses:

a) Supply-driven: actions that transfer and commercialize technologies of governmental research programs to private firms. These actions are directed to industrial firms with low technological capacity, as well as to high technological sectors. This model was adopted in Canada by "Canadian Space Agency";

b) Demand-driven: actions that usually are initiated by firms that aim to identified technological defects, considering both opportunities and needs from marketing, particularly at small businesses. This model was adopted in the USA and by The Manufacturing Extension Partnership;

c) Network-based: most of these actions are executed at a regional level, guided by the

institutions which promote partnership between the firms, essentially a technological information programme. This model was adopted in Netherlands by Dutch Innovation Centres,

d) Infrastructure-building: actions that deal with effective improvement of the technological diffusion system infrastructure at a national level. This model was adopted in Korea by Regional Research Centres and in Brazil by the Science and Technological Ministry through Basic Industrial Technological Program.

It is worth to remember that there are many countries where there's a big diversity of technological diffusion actions, which reflect not only their innovation systems in general, but also their specific systems and the regional economic dynamics. The technological diffusion programs referenced by OECD show methodologies already consolidated in some country members and methodologies at an initial phase and implementation in the developing countries.

In general these methodologies are guidelines formulated in the governmental context and are articulated by different agents, for instance, universities, enterprises (particularly SMEs), non governmental organizations, and research institutes. These agents work together to formulate all actions and to promote innovation development in the country. Table 2 in annex represents some examples of technological diffusion programs adopted in the USA and Canada.

Both programs represented in table 2 are promoted by governmental entities in partnership with universities and technological institutes, which offer technological services specially within SME in the adaptation product area, process and administrative management. Another similar feature from these programs is the methodology used to offer a service: 1. The presentation program phase and diagnose made by expert; 2. Good practice proposal phase or improvement of organizational programs and, 3. Implementation proposal phase.

Technological extension within SME

Considering all strategic management factors, technological diffusion can be emphasize as the one being the most complex and of great risk, but at the same time being the one which has more potential to guarantee good results.

Aiming to reduce the risk of failure of technological innovations, especially those related to consumer goods, there is a need to merge the "market reality vision" with the "prospective market vision" in terms of novelty.

This fusion will occur only on its total plenitude, when the essential factors to the well known "good practices" in management and mainly at production are perceived/understood by customers in terms of improving the quality of products and services. These "good practices" consist of simple actions, low cost and high impact at production and development, involving

the revision or improvement of product/process, and that are appropriate to the business at stake/in question.

In this sense, the prospective market vision deals with the sense of the novelty, which can arise by an implicit perception (market push), or as a positive attitude of acceptance of certain technical feature (technology pull). The process, product or service that may arise would be affected in/at applied research and still being tested in a format product/process and technology.

These moves follow the strategies of firms in two models presented as Imitative or Innovative Model (Hayes and Wheelright, 1984). The technological institutions that have a concern with education, development and dissemination of technologies can be brought closer to the reality of companies, universities and research centers.

These technological institutions, in most cases, have as a mission the training of personnel for technical and technological professions and the provision of technological services, which do not necessarily include the advancement of knowledge from research institutions, because they are more related to technical training and assistance to the dissemination of basic knowledge of production processes. These resources of knowledge are prepared to address the needs of the majority of micro, small and medium-sized enterprises.

Likewise, the universities and research institutions should be recognized as institutions prepared to assist in the above mentioned "prospective vision". When we identify the "arm" of the research, because of dealing intensively with the advancement of knowledge and interaction in a scenario without borders/obstacles. Another arm, the one from extension seems to be stigmatized in the traditional way in continuous knowledge, that means, courses or training. The partnership projects between universities (research centers) and companies that aim technological advancement may lead to an interaction between the business and science vision.

In this case, the adjustments of the forms of action aiming to a greater interaction should be developed not as simple contracts for commercial purposes, but as partnerships between the "technological experts" and "market experts". In this context this partnership should occur by presenting each part its "core business", even though the results are at the beginning not satisfactory. The adjustments in focus and in the daily practices of both institutions are expected and include, among other activities, the development and use of knowledge in issues of confidentiality of information, in timing of the request and response and on the work methods that should be developed or adapted.

The process of developing products and processes is the responsibility of companies. The natural risks that arise from testing new technologies, can be minimized with the use of partnerships between state, technological centres/research and companies.

In this sense, companies should not be waiting for research centers to develop complete products or

processes, but they should develop their own prototypes and tests in laboratory scales. As a result, some scientific articles arised and eventually some patents, specifically for products or processes. This is a real result from the capacity of the company to innovate, of great strategic importance due to differentiation, even temporarily, of products and services from the competition and the consequent opening, maintaining and growing market.

How to trasmit/pass accumulated knowledge from universities and research centers to the public opinion without using the traditional extension concept from the university? One answer lies on the well known technological extension concept, recognized has having big impact at the economic development by the OECD. The technological extension is considered an important action within the context of leveraging technological innovation in SMEs. In the reference books from OECD (1997) there are reports from the beginning of 90ies from some country members that have launched initiatives and consulting services for networking, using Information Technology - IT. The aim was to help companies to adopt new management good practices, to implement organizational changes and to direct habilities of workmanship considering the interest of general improvement, all around innovative capacity and use of technologies.

To direct the research study within SMEs, it appears to be lacking some basic systems of quality management and strategic vision of their managers. It is considered, besides the factors of cash management, staff and production, the awareness of the importance and the need for further investment in time, as well as the accumulation of knowledge, financial, material and human resources to improve competitiveness. These topics are the main factors that impeded/threat the innovation process. Thus, the companies that have growth potential with the aid of technological extension services can be internationally very strong and disseminate the culture of innovation and therefore be able to continue progress in R&D activities.

Moreover, technological institutions seem to be the most appropriate place for the development of technological extension services, requiring it to:

1. Methodologies of attendance and managerial and technical advices (proposals), assistance (to do with the firm) and services (to execute or provide services outside for firm);
2. Trained and qualified personnel in the methodology;
3. A technological network that links these institutions and services of the technological extension, the research centers and universities.

Today, the actions related to extensionism are not sufficient to meet the needs of SMEs. Several problems can be pointed in the actions and potential customers, according to the author's view:

1. Lack of an appropriate methodology to various kinds of economic, technological and social changes that affect SMEs;
2. Lack of qualified staff to attend for the SMEs;
3. Lack of focus on technologies that are considered basic and concern with problems that often boil down to investments in machineries;
4. Attendance of the variety of demands; industries, commerce and service, without any specifics for sector of the industry;
5. exclusion of the SMEs.

Capital goods sector specification

The capital goods sector includes a set of machinery and equipments manufacturing firms, which are responsible, to a great extent, for the capacity of production of other products. A capital good may be thus considered when it is used in the productive process of other goods and services.

The capital goods sector is directly related to the value chain of the other industrial sectors, but it is also a consumer of goods produced by itself . In this manner the capital goods sector has an important role in the diffusion of new technologies and as a dynamic economic growth sector. It gathers several kinds of products used for many purposes, which can be divided as follows:

- Mechanical capital goods – mechanics, mechanical equipment, industrial equipment, agricultural machinery and implements, mining and road machinery;
- Transportation equipment - buses and trucks, naval, aeronautic industry;
- Electric/electronic capital goods – electric and electronic equipments.

Therefore the capital goods sector is directly related to other production sectors and has a relevant role concerning the diffusion of new technologies (Sandven et al, 2001). It could be distinguished by its heterogeneity, (different uses and kinds), purposes and client sectors (chemical, petrochemical, metallurgic, textile, shoes, electric, paper and cellulose, food, etc.).

In Brazil the firms dealing with the capital goods sector are leaded by the dynamics of other industrial sectors. These firms work for those other sectors, producing their equipments. The producers of capital goods dealing more with the internal market show, in a general way, a low innovative effort, which reflects the features of those firms that buy those goods, as well as a continuous and slowly machinery obsolescence.

The national producers have the need of developing product technologies with a broader internal scope. However interactions with universities and research institutes are low, in other words, ther is insuficiente use of the available national and reduced sources of

knowledge. The majority of firms within this sector reveal the difficulty of developing projects together with other firms, research institutes and universities, claiming timing divergences... At the same time, many firms have also admitted that they can not spend more efforts to set a long term bound with those educational and research institutions. The way to be in continuous contact with the market is made directly through market fairs, making thus contact with customers and suppliers to decide technological strategies.

METHODOLOGY

This study was conducted in fifty SMEs in the capital goods sector in São Paulo state. This pilot project was implemented in partnership with Ministry of Science and Technology of Brazil, which allocated the funds for the project, and the Institute for Technological Research – IPT, from São Paulo, that executed the project.

The project was developed by presencial and laboratorial actions, aiming at product and process flows, in a way that indicators about the period before and after those actions could be obtained. Thus it was possible to build a comparative framework. The work IPT conducted managed within the firms was as following:

1. Directional service to the management of products and process flows ;
2. Use of national and international technical standards, technical regulamentation to be applied to the product and embedded in good practices of production to be implemented;
3. Corrections on the management of the process flow and on its associated variables;
4. Consultory and/or recommendations on general problems diagnosed within the firms, with long or medium term impact;

The first phase was to achieve a technical diagnose, which was gathered through data collection the productive process in a general way and its variables (cost, time, rework, stock, defects, delivery time conditions). In this manner, the data which was set could help to identify and to discuss all the involved aspects of the productive flux, considering the management, organizational, productive, financial, administrative, data flux and technological difficulties level.

The second phase was to constitute a relationship between the above mentioned topics and after that to select the most important to the customer. In a way that could be used to focus on the aspects which should disseminate correlated actions within the firm. A global methodology was then proposed to serve the aims and to set up a work plan to be discussed and approved by the businessman. After the approval a work cronogram was prepared within the firm, so that the identified actions could take place.

RESULTS

The main results achieved by SMEs were the following:

1. Costs reduction without reducing operational capacity;
2. Planning improvements and a better control of the material and production processes;
3. Stock reduction;
4. Better punctuality delivering their products.

It can be deduced that the pilot program's technological extension proved to be relevant to SMEs due to specific management actions focused on the real needs of each firm. In the beginning this was a new and unknown project, and many businessmen manifested doubts and uncertainty concerning the program. But after the evaluation, the process of implementing the pilot project was suggested, executed and further extended to other sectors in São Paulo. With the enlargement, it was achieved a better promotion and publicity as well as the adoption of the concept of technological extension. The program became thus effective as a part of the Science, Technology and Innovation Program promoted by the Brazilian government.

During this work, it was possible to be aware of a new perception of the real technological development at the capital goods sector. It was observed the opportunities and tendencies among other researchable topics.

In these sense this work contributed also to the industrial politics in the sector, searching for a better dynamism, technological independence, competitiveness, as well as to the industry and economy of Brazil. The politics experts agree with the study and therefore decided to discuss some new politics, considering the productive and technological development of the national sectors in general, specific in the capital goods sector.

CONCLUSIONS AND FURTHER RESEARCH

Innovation is fundamental to the strategic industrial development of a country. The use of new technologies within the firms implies assuming inherent risks on development, production and the pilot commercialization of products and services. The strategy used to innovate becomes an important factor to improve competitiveness.

Innovation is not associated only to the desirable speed of high competitive environments. It should be present in simple solutions, systemic and not restricted to R&D areas. It should also include main aspects from the business of the firm.

In this context, the government has an important role as an introducer of innovative technological processes within firms and thus promoting cooperative actions/initiatives (technological institutes), financial resources and support to the implementation of

technological programs, as a form to strengthen the economy, and the creation of wealth and employment. It should be emphasize the role of the technological extension programme at progress, which has contributed to create an competitive environment to innovation, offering SMEs an appropriate technological infrastructure of experts, services and knowledge centres. It thus contributes to the strengthen of the technological plataforms of a country, focusing on the constitution of a prosperous society kown as knowlede society. The program has revealed to be of great importance to the SMEs. These firms were supported because of their management actions focused at their real needs, bound to technological support and low investment. The suggested actions always have been taken considering the actual/real resources of each firm.

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Table 1 – Financial Investment Distribution (%) in Innovation according the firm size

Kind/type of Innovation	Distribution (%) of the total investment (R\$ 22,35 billion)	Distribution (%) according the firm size		
		10 to 99 employees	100 to 499 employees	More than 500 employees
Equipment and machinery acquisition	52,2	71,73	64,69	43,11
R&D Internal Activities	16,75	10,07	11,66	20,17
Industrial Project and other technical prepares	14,76	9,5	11,84	17,05
Introduction of Technological Innovation in the market	6,26	3,22	3,99	7,96
Other External knowledge acquisition/contract	5,26	2,04	4,80	6,12
Training	2,82	1,04	1,01	3,90
R&D External Acquisition	1,87	2,40	2,01	1,96

Source: IBGE, Research Directory, Department of Industry, Industrial Research – Technological Innovation, 2000

Table 2 - Examples of Technological Diffusion Programs in the USA and Canada and its action/proceeding areas within SMES

INSTITUTION - COUNTRY	PROGRAMS	action/proceeding areas	
		PRODUCT and PROCESS	GESTAO ADM
National Institute of Standards and Technology - EUA	Manufacturing Extension Partnership (MEP)	Lean Manufacturing Quality and Certification Environment, health and security	Strategic management Information Technology - IT Human resources management
National Research Council Canada - Canada	Industrial Research Assistance Program (IRAP)	Lean Manufacturing HPM – High Performance Technological Manufacturing Technological Transference Intellectual Property Technological Information and services network	Business excellence Information Technology - IT

Source: MEP, 2005; IRAP, 2005.

TECHNOLOGY EVALUATION AND LICENSING: A LITERATURE REVIEW AND AN ASSESSMENT OF THE PORTUGUESE UNIVERSITIES TECHNOLOGY TRANSFER PRACTICES

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Technology evaluation and licensing, intellectual property rights, technology transfer

ABSTRACT

To improve the access to information about practices supporting the application of research results we looked at strategies and methods described on the literature review and in use by technology transfer units (TTUs) having in mind a set of questions underlying the processes of technology evaluation and licensing in universities. The research questions gave us the opportunity to understand the TTUs degree of selectivity in the protection of inventions, the factors at the origin of licensing agreements and its main obstacles, the main evaluation methods and payment modes and they also gave us the opportunity to know the universities at study structure of dividend distribution. Underneath the answer to this questions we affirmed that the development of complete and demonstrable turnkey solutions and products decreases the investment risk and makes the technology more attractive to potential licensees, and we concluded that only knowing the economic value of an invention can we fully exploit its full potential and can we carry out an appropriate technology valorization strategy.

INTRODUCTION

The protection and transfer of intellectual property rights allows the combination of the unique features of an invention with the needs and interests of companies' economic development, converting the scientific and technological production in new or improved products and processes. Foreseeing this end, universities have adopted knowledge valorization strategies to foster the practical application of research results. In this context, technology evaluation and licensing activities allow inventors and universities to obtain revenues through the establishment of technology transfer agreements. In order to understand this process and to improve the access to information on specific practices to support

the commercialization of inventive activities this paper addresses the following research questions:

- What's the technology transfer units degree of selectivity in the protection of inventions?
- What factors are at the origin of licensing agreements?
- What are the main obstacles to technology transfer?
- What are the main evaluation methods used in technology transfer?
- What are the main payment modes used in licensing agreements?
- What is the structure of dividend distribution within universities?

The answer to this set of questions is provided through the development of an integrated and systemic approach to the process of valuation of intellectual property rights pursued by universities, under a well articulated set of concept, meant to generate a holistic body of knowledge where the comprehensive literature review is minted with information and data concerning the technology transfer activities realized by Portuguese universities. This structure gave us the opportunity to articulate and unify the main technology transfer concepts presented on the literature and it made possible to identify and present methods and strategies to improve and promote the practices of technology transfer professionals. Although the results must be read having in mind a specific national delimitation and context, we believe that the results reflect other realities and may constitute a basis on which further research work can be developed.

METHODOLOGY

This study involved seven Technology Transfer Units (TTUs) from seven Portuguese universities. This sample was purposefully chosen due to the regional influence of the university, the geographical proximity to obtain information and due to the experience and ability of the TTUs to provide data that would expand the understanding of technology transfer processes.

Information collection was achieved through a triangulation process where the knowledge and practical experience of the TTUs head of staff, obtained through personnel semi-structured interviews and a questionnaire, have been minted with a comprehensive literature review to gain a rich insight into the evaluation and licensing processes.

Through the collection and analysis of data which is mostly qualitative, and through the extensive literature review that was made, a well integrated set of concepts have been brought together to advance and generate a sequential body of knowledge which allow us to clearly articulate in each section the TTUs inputs with the literature state of the art to answer this study research questions under a systematic articulation and integration process.

Table 1: Research sample of higher education institutions and their respective technology transfer unit

University	Technology Transfer Unit
University of Aveiro (Universidade de Aveiro)	UATEC – Unidade de Transferência de Tecnologia da Universidade de Aveiro
University of Beira Interior (Universidade da Beira Interior)	GA-API – Gabinete de Apoio A Projectos e Investigação
University of Coimbra (Universidade de Coimbra)	GATS – Gabinete de Apoio à Transferência de Saberes
University of Minho (Universidade do Minho)	TECMINHO – Associação de interface da Universidade do Minho
New University of Lisbon (Universidade Nova de Lisboa)	GAPI do Madan Parque – Parque de Ciência e Tecnologia
University of Porto (Universidade do Porto)	UPIN – Universidade do Porto Inovação
Technical University of Lisbon (Universidade Técnica de Lisboa)	OTIC-UTL – Oficina de Transferência de Tecnologia e de Conhecimento

THE UNIVERSITY TECHNOLOGY TRANSFER UNITS (TTUS)

Technology transfer units are meant to evaluate, protect, and support the researchers on their efforts to obtain resources and to diffuse and transfer their inventive results (Young, 2007), and their instruments to enhance the university-industry relations (Siegel et al, 2003; Debackere and Veugeleres, 2005). They also negotiate licensing agreements and they support the creation of spin-off companies (firms created by university staff members, which aim to commercially exploit the university inventive results) (CEC, 2007). These technology valorization units also administer the licensing agreements and equity participations, they manage the licensing financial earnings and they proceed to its distribution according to the university intellectual property rules, and as a rule of thumb, the closer the proximity between the TTU and the

researchers, the more efficient they will be on the establishment of mutual supportive relations (Dodds and Somersalo, 2007) which are essential to encourage the researchers to share, on a regular basis, information about their research activities and results (Di Sante, 2007) and to promote the knowledge and technology diffusion and the appropriation of economical benefits. The communication of research results is what triggers this valorization process, meant to match the invention characteristics with the firms' development needs and aspirations. Since the results disclosure until the association of an invention with a commercialization path, the TTUs assume valuation principles and proceedings influencing the methods and practices of technology evaluation and licensing, conditioning the universities selectivity level on the protection and territorial expansion of intellectual property rights. To understand these principles and proceedings the following sections will present an integrated literature review minted with the inputs brought by the information collected among technology transfer units.

THE LEVEL OF SELECTIVITY IN THE PROTECTION OF INVENTIONS

Technology licensing is positively correlated with the number of registered patents (Shane, 2004), and the number of invention disclosures, the money available for research, and the number of technology transfer professionals influence the number of licensing agreements (Chapple et al, 2005). Universities receiving funding from firms perform more applied research, cooperate more with external researchers, either from industry or from other universities, and register a larger number of scientific publications and entrepreneurial results (Gulbrandsen and Smedy, 2005). The number of registered patents tends to be higher when there's an effective collaboration between the researchers and the TTUs (Saragossi et al, 2003), and the protection rate enhances the impact of the patent portfolio (Owen-Smith, 2003) and there's a high correlation between the development of significant patent portfolios and the number of scientific publications (Stephen et al, 2002, cited by Godinho et al, 2008). The universities with a higher number of publications are also the ones registering higher rates of intellectual right (IPR) protection. On the other hand, the number of patents doesn't reflect the impact that a university has on the economy, and the number of patents, on its own, doesn't describe the nature of the inventions nor their commercial value (Agrawal and Henderson, 2002). This last sentence raises the question of selectivity, and its significance on IPR protection. Selectivity on patent applications has a major impact on the TTUs performance (Powers and McDougall, 2005). A large patent portfolio requires greater resources and eventually there may be a need to concentrate the commercialization efforts on a reduced number of

technologies to bet on those who present a stronger market potential (Gardiner, 1997). It's essential to patent the invention on a strategic way, and the technology transfer professionals must be prepared to spend time, effort and money on this task, as it seems to be one of their most important ones (Dodds and Somersalo, 2007). The decision to patent must be influenced by the invention market potential and not by its scientific excellence, nor by the will of the inventor.

Among different TTUs it's usual to find distinctive selectivity levels and protection strategies. The more selective TTUs devote more time and resources on a smaller number of high-potential inventions and they prefer to patent by making a previous estimation of future patent and management costs to protect future dividends and to avoid copy and they also take into account the probability of finding suitable partners. The less selective TTUs seek to increase the number of patents to motivate the researchers' productivity and their culture and experience on writing patent applications. We can also find non selective units when applying to national protection, but they do perform evaluation work and they do identify potential partners to be selective when applying to international protection rights. This strategy has the disadvantage of potentially creating a large patent portfolio, which is costly to maintain, and difficult to manage (transfer), and usually the existence of a large patent portfolio isn't related with a larger number of licensing agreements, and as a rule of thumb, TTUs don't have all the resources necessary to expand internationally the protection of patents which are not expected to generate revenues, either via the European way or via the Patent Cooperation Treaty (PCT). Selectivity in the geographical rights expansion is important and some TTUs use the services of Brokers instead of internally managing the patent portfolio, since the costs of Brokers services may be compensated by the costs they didn't incurred with the management of a very large patent portfolio.

After having decided to patent arises the need to define the technology diffusion strategy. The next section addresses this issue.

THE LICENSING AGREEMENTS ORIGIN

To transfer a technology we must find a window of opportunity (Abell, 1980) to match, in the right moment, the characteristics and advantages of a technology with the firms' needs and interests. The window of opportunity is the moment on which the firms see a technology as being useful to correct, value or introduce a product or a process on their value chain, to gain a competitive advantage and to be able to maintain or conquer market share. The right timing for the technology introduction should be aligned with the firms' product replacement cycles, because if the replacement is made too soon, the firm may incur in

high change over costs, but if a company replaces a product too late it may lose market share (Abell, 1980; Gatignon et al, 1997; Speser, 2007). The identification of firms willing to replace or to update existing products or processes, or willing to diversify its product range is the window of opportunity were looking for, and the lower the introduction costs, and the better the technology adequacy to the firm needs, the higher is the invention value and the probability of licensing it.

With the aim of opening and to take full advantage of the window of opportunity, a firms identification strategy must be adopted, coupled with a marketing and diffusion strategy to present the invention value proposition. The next sections address these issues.

The firms' identification strategy

The firms' identification strategy must include, in addition to the market and technology description, the identification of the competencies and resources which are necessary for its development and commercialization. A good licensee or technological partner is the one who's able to complement our present resources and competencies to make our invention viable. The referred actions and the appraisal of required resources presupposes an assessment of the development, production and distribution stages of the products or processes which will include the technology. During this analysis, we should have in mind, the firms' skills and their production capabilities, as well as their competitive strengths in terms of products, distribution channels, marketing and sales force, to find licensees able and willing to support the technology market penetration. This analysis can be enhanced if a SWOT procedure or a 4Ps marketing analysis (product, price, promotion, point of distribution) is followed (Di Sante, 2007), this may be helpful to determine what's necessary to commercialize the invention and to assess and select suitable firms to access markets and to raise its value for both parties and final-consumers.

We also need to determine what intellectual property rights are required for the technology to function as a product or integrated in a product or in a larger platform (Di Sante, 2007), what knowledge must be transferred to the licensees, and we need to assess if the firms are able to absorb it. It's also desirable to understand how the technology fits within the firms' technological space, with whom we intend to negotiate, so that an alignment between the technology characteristics and the firms' capabilities and resources is achieved.

While determining the invention potential and attractiveness and while we identify potential partners, we must determine the technologies that have to be integrated with our invention to obtain a complete commercial product, and we need to analyze the possibility of combining the technology with existing products or systems, we should also measure the

possibility of producing the technology on a large scale and with what resources and skills. The technology friendly use, its easy and intuitive reproduction and packaging, its robustness, its adaptability to different environments, and the user possibility to perform tests to decide on its usefulness are also relevant factors on technology licensing decisions (Thornatzky and Fleischer, 1990), they also influence the licensees perception of risk. As a rule of thumb, smaller firms and start-ups are the ones willing to assume greater risks and more experimentation to test what might work, larger firms have more pre-established compromises and are less flexible in the adoption of new technologies (Speser, 2006). Established enterprises have a preference for incremental technologies, which bring something new to an existing invention or who alters its design (Shane, 2004). Smaller firms are more willing to adopt technologies in initial development stages, or technologies that present disruptive characteristics allowing the development of new generation products based on different scientific domains (Thursby et al, 2001; Shane, 2001).

Independently of the firms' maturity and size, the technology adoption is under the dependence of the firms' strategic orientation (Miles et al, 1978). Firms whose growth is more dependent on new products and processes continuously seek new technologies and business opportunities, and their usually potential licensees to be looked for. But our technology may not be the only one to solve a particular problem, and it may be useful to existing firms willing to remain competitive or to insurgent firms willing to compete with established players. Therefore, we must pay attention to existing patents leading to the same results and to their owners, so that the search for licensees is oriented to those firms requiring new technologies to maintain or acquire a competitive position. The patenting and articles publication rhythm in certain areas, their respective owners and their applications should also be accompanied, as well as the importance and value of different patent subclasses. We should also bear in mind that firms who commercialize previous or similar products are typically good licensees.

The technology complexity level and the market that a firm commands are also important factors to bear in mind when searching for a licensee (Speser, 2006). In short, a good development and commercialization partner should:

- Have adequate technological capacities and competences;
- Have the necessary networks and resources;
- Have a significant client base and a strong brand;
- Be able to address the relevant market segments targeted by our technology;
- Have a risk taking attitude.

The main purpose is to create and develop new solutions and to gain uncontested market space (Kim and Mauborgne, 2005).

The development of complete, demonstrable, turnkey solutions and products decreases the investment risk and makes the technology more attractive to potential licensees. We should notice that many solutions are licensed not because they embed an innovative technology, but because there's a complete product, which includes a patent, whose functionalities have been demonstrated on the ground. However, it's not always possible to license the technology to the firms we consider to be the most suitable to develop and commercialize it, because firms may have no interest on the technology, or may not be interested on it at that particular time for strategic reasons. When isn't possible to license to the most adequate partner, and because it's usually better to obtain an agreement than to not obtaining it, then the TTUs normally prefer to license to the firm that's quicker in manifesting its interest. When other firms, a posteriori, offer more value for the invention, the TTUs don't step back and uphold the partnership with the firm their working with, to enhance the collaboration previously established, being the TTUs general perception of a good partner, associated with their capacity to initiate a large scale production, to access the required networks to address the relevant markets and, above all, the TTUs look for a credible partner, that respects deadlines and meets the defined targets and that negotiates fairly so that each part feels that a balanced agreement is achieved.

Having clarified the profile of the firms to be contacted, the next step is the technology marketing and diffusion, an issue to be addressed in the next section.

Technology diffusion

The licensing agreements origin is associated with the size and quality of the TTUs and researchers networks - "one's worth can be approximated by the size (and quality) of one's network" (Kolchinsky, 2004:95). TTUs acknowledge that the inventors are the most important source of licensing contacts (Hsu and Bernstein, 1997), and they're the primary source for firms identification (Thursby and Thursby, 2004; Young, 2007). Inventors can be a "one stop source of market information" (Di Sante, 2007), and the inventor direct contact with firms is the most important factor on the establishment of licensing agreements, the second most important one is the TTUs marketing efforts. Agreements obtained by inventors are made predominantly with larger enterprises, while the agreements obtained by TTUs are made predominantly with smaller firms. The explanation seems to be related with the fact that smaller firms have fewer resources to invest on technology watch and are more receptive to the information provided by the TTUs communication channels. The TTUs investment on direct marketing

intended for smaller firms may prove more useful than the marketing directed to larger enterprises (Ramakrishnan et al, 2005). On technology diffusion it's also important to consider the university prior relations with firms and their geographical proximity (Mansfield and Lee, 1996) and strategic position and location, to extend our present collaboration networks having in mind that the majority of the university-industry relations are informal (Mowery and Nelson, 1999), and multiple communication channels should be used to effectively communicate the technologies value proposition. The TTUs recur to these informal networks of contact to assess the invention technical and market potential, to identify companies potentially interested on the invention, to raise money for further developments, to support spin-off companies' creation and to determine the patent territorial expansion opportunities. These informal networks are composed by different economical, technological, governmental and entrepreneurial stakeholders. Another important factor on the origin of licensing agreements is the development of technology tailored to the firms' needs and requests. To respond adequately to those needs and requests, many TTUs make regular and comprehensive updates of the university scientific and technological supply, arising projects, initiated either by the firms, the TTUs or the researchers, and their aim isn't only to patent and license, but also to solve specific problems and to take advantage of governmental (or other) programs supporting R&D activities.

The previous licensing agreements, the contact with former collaborators and students working in the targeted industry, and the contact with firms beyond the region are also relevant factors on the universities technology transfer processes - the Portuguese speaking countries, including Macau, but specially Angola, are considered by the Portuguese TTUs as very important markets for the development of new projects, but as a key trend, the TTUs interests and actions are oriented to the expansion of their international connections beyond their traditional lusophone markets.

In short, the TTUs recur to multiple communication channels to diffuse the technologies value proposition which must be a concise and quantitative presentation of the problem (and the reason why the consumer will adopt the solution), the identification of the market, its size, the economic and social benefits for the adopters and its comparison with competing technologies and solutions (Gomes, 2007).

Beyond the technology value proposition diffusion and the establishment of industry relations, it's important to make an integrated management of the units that support entrepreneurial activities and technology transfer processes, to enhance the relationship between the researchers and knowledge valorization professionals and to improve the definition of integrated commercialization strategies. It's also important to foster a more structured relation between the university

departments and research centers, and the technology transfer professionals to monitor the development of projects from their inception until their diffusion.

The technology diffusion enhances the application of research results and ensures further resources, clients and new projects, and there are essentially four options for an effective technology transfer process:

- The inventor creates a new enterprise to commercialize the invention;
- The invention is integrated in a larger product or system and solves a firm specific problem. In this case we already have at least one potential licensee for our invention.
- The researcher makes an invention to solve a firms' problem with whom he's already working. In this case, the licensee will be the firm.
- The inventor delegates the technology commercialization responsibility on an external entity. This last option is the one that's less likely to succeed. The inventor must be actively involved on the technology transfer process, he also has to try to sell or license the invention by himself or with the TTUs collaboration.

The inventors' engagement on technology licensing processes is essential, and this is well acknowledged by the TTUs, who recognize that behind their success and growth are the relations of trust with the researchers and their informal networks. Together, they provide a powerful framework for an effective internal and external communication strategy. Being the TTUs a "value shop" that manages a network of actors and technologies, providing support to researchers during the knowledge valorization processes (Stabell and Fjeldstat, 1998).

OBSTACLES TO TECHNOLOGY TRANSFER

All communication and licensing strategies encounter obstacles, knowing them is a good principle to avoid or to work to surpass many of them. Some of the obstacles are the TTUs lack of experience on the evaluation and licensing processes (Collins and Wakoh, 2000; Chukumba and Jensen, 2005), the location of the university in a poor technological developed region, the universities lack of a clearly defined mission towards the support of technology transfer (Friedman and Silberman, 2003), the availability of financial resources (Dodds and Somersalo, 2007), the reduced number of technology transfer professionals (Ramakrishnan et al, 2005), the brand value of the institution and the lack of previous connections with industry (Harmon et al, 1997). Other obstacles associated with the universities technology transfer practices include: information deficiencies, insufficient technology watch, deficient marketing strategies, difficulties in finding business partners with adequate capacities and resources for

further technology developments, the lack of entrepreneurial initiative, their inability to determine the technologies investment risk, and the lack of administrative support on the elaboration of financial applications and in project management (Arvanitis et al. 2005).

The early-stage of technology development, the inexistence of a final product, the uncertainty in cost estimates or profit margins, the lack of TTUs commitment in a line of business, and the mismatch between the technology specifications and industry requirements (Kristofferson and Jonsson, 2003) are additional barriers to technology transfer.

References about the lack of engagement between university researchers and industry, and the lack of research programs devoted to technology study and transfer, as well as, the lack of an integrated management of the protection, transfer and entrepreneurship activities among the universities and the lack of a proof-of-concept fund in some universities, are other obstacles appointed by the TTUs.

In short, it's important to understand the technology transfer and licensing barriers, in order to find efficient solutions and alternative ways to surpass them. Understanding the invention and its market and the identification of suitable firms seem to be important components to overcome some barriers. Another important factor is related with the assessment of the industry motivations to collaborate with universities and with the demonstration of the engagement advantages.

EVALUATION METHODS

The technology evaluation and the assessment of its commercialization potential is a transversal task that sweeps across the technology transfer process, allowing us to surpass some of the referred obstacles. Since the invention disclosure until the patent license or assignment several evaluation methods can be used. At an initial stage of the invention evaluation process, the TTUs tend to use quick evaluation methods, based on checklists and on the preparation of short reports about the invention market and return on investment. At a posterior stage, a more in depth evaluation is carried, and comparable agreements, royalty standards and cash flow projections are used. The more in depth study is usually initiated when the TTUs receive a manifestation of interest or when the TTUs need to obtain additional information to strengthen the technologies presentation to potential investors. During this evaluation process we want to know and understand everything about the technology, and no one understands it better than the inventor (Di Sante, 2007), being the inventors engagement essential throughout the entire technology transfer process.

Among the most important TTUs activities to understand the invention are the analysis and description of the technology, its attributes and claims,

the identification of new development stages and the definition of an action plan or an industrial map specifying what to do and what can be done to bring the technology to the market. It's also important to identify competing patents with the same purpose of the invention, and to identify all the invention applications for the patent protection to be as wide as possible and to identify the strongest link between the invention, its solutions and its market. To enhance this link and the engagement with industry it's important to build applied R&D projects on a clear identification of the targets and markets to be met, knowing what are the applications to be built and what's the added value against existing solution, in this way, we can define, from the beginning, clearer research lines which might lead to technologies and patents with higher profit potential, and as a good practice, we should always base a research project on a deep patent search, this procedure may reduce to half the project duration and it usually brings, on average, a 40% reduction on the research costs (Smith, 2005).

The identification of competing R&D teams, the analysis of alternative technologies likelihood to show up and the assessment of the possibility to redesign the invention through reverse engineering are also assumed by the TTUs as important activities.

In this stage of technology understanding and evaluation, we want to know every aspect of the invention and to clarify all the tasks which are necessary to obtain the invention proof of concept (if not already attained) and to obtain a complete commercial product. The proof of concept is essential to develop products based on the technology. The lack of a proof of concept national fund is a weakness remarked by many of the Portuguese TTUs.

After all aspects of the invention have been understood, and after the assessment of existent resources for new development stages, it's important to select the invention most promising applications to deepen its market study. The market research is the starting point to analyze the relationship between the technology, its applications and its market, identifying its final consumers, needs, competitors, and the relevant firms and actors, so that an adequate market position can be found. It also enhances the invention value proposition and diffusion strategy. The market research is initiated, by the TTUs, at the moment of the invention disclosure and it's usually deepened during the period that's between the patent registration and the PCT requests or when a manifestation of interest is received.

To obtain data about the invention and its potential market there are several methods with different levels of depth which can be applied at different times of the evaluation process.

The most common methods are:

- Pre-defined evaluation models and matrices;
- Comparable licensing agreements and the observation of royalties practiced in industry;

- Evaluation based on development costs;
- Discounted cash-flow method;
- The 25% rule;
- Real options and Monte Carlo simulation methods;
- Patent auctions.

In the following sections we address each method separately.

Pre-defined evaluation models and matrices

Methods based on checklists and on pre-defined models speed up the evaluation process and facilitate the consideration of multiple dimensions of the invention, from its intrinsic quality to its market potential and profitability. These methods are the most widely used instruments in the evaluation of invention disclosures. Some of those instruments are:

- COAP – *Commercial Opportunities Appraisal Process*, developed by Warwick University, in which ten evaluation criteria are scored;
- *Rapidscreen*, it's a process supported by a web service to discover the opportunities associated with early stage technologies, which involves conducting interviews with the research team and with experts in the technical field under analysis;
- *IPscore 2.2.* developed by the European Patent Office, was designed to identify potential gains and opportunities, and to reduce the evaluation time and costs, and can be used to study ideas, R&D projects and patents providing us reports about a patent or a set of patents and presenting a forecast of the net present value of the assets under analysis.
- *Commercialization Quicklook Assessment*, developed by the University of Texas, consisting in a four steps study allowing the collection of information to prepare a final report about the technology commercial potential.

Beside these matrices some TTUs have built their own evaluation methods which usually group a set of indicators into four major categories: the technology stage of development, the innovation potential, the market potential, and its strategic importance.

Comparable licensing agreements and the observation of royalty standards

The analysis of previous licensing agreements and the observation of royalties practiced in industry (royalty standards) may provide guidance to define and defend the payments structure and its value during the negotiation of a technology transfer agreement (WIPO/ITC, 2005). The search for comparable license agreements and royalty standards is an effort that usually pays off (Razgaities, 2003), although the specificity of each technology doesn't call for standard

agreements. But it's important for the TTUs to build and maintain a portfolio of reference agreements which can be used if needed (Dodds and Somersalo, 2007).

Databases and publication with royalty standards and licensing agreements are a good source of information to understand the invention value and potential return. The "Royaltystat" of the US Securities and Exchange Commission, based on the Edgar Archive, is a well known database where payment structures for many technologies acquired by US firms can be consulted.

Evaluation based on development costs

Evaluation based on development costs is rarely a base on which firms negotiate license agreements (Razgaities, 2003). Firms are interested in obtaining technology in an easy and cheaper way than it would cost if they developed the technology by themselves, and the cost of creating a technology has nothing to do with its value (Speser, 2006). The market value is a more appropriate metric for evaluating a technology (WIPO/ITC, 2005). The evaluation based on development costs shouldn't be used to put a price on a technology, instead, it should be used before the start of a project as a way to estimate future costs and future investment.

Discounted cash-flow method

The discounted cash-flow method is widely used by organizations who deal and license technology (Degnan and Horton, cited by Kemmerer and Jiaquing, 2008). The discounted cash-flow calculus is important for business profitability discussions and to provide a basis for setting up royalties and other payments. It's also important when the deal involves a single lump sum payment for the utilization of a technology during a specified period of time, or when the creation of a firm is under consideration, providing a basis for equity participation.

The 25% rule

The 25% rule is usually applied to the EBIT – Earnings before interest and taxes, and was defined by Goldscheider et al (1970) according to Kemmerer and Jiaquing (2008), suggesting that the licensee pays a fee equivalent to 25% of the invention contribution to the operational results obtained by the product that embodies the technology. The 25% rule divides the value of a technology in four parts: the creation of the invention, the preparation of the invention for industrial reproduction, industrial reproduction, and the sale of the invention, per se, or incorporated in a larger product. Each one of these parts represents one fourth of the invention value and, in this sense, the invention is one of four parts by which the commercialization gain is distributed. If the invention is already prepared for commercialization, it makes sense to define a larger

value, say 33% or more, since the invention has already attained a threshold that includes production. In the case of software, these values can ascend to 50%, since the technology is ready for commercialization (Razgaities, 2003).

The rule is a good starting point, adopted by licensors and firms, for royalties' negotiation, thanks to its simplicity, intuitive reasonability and diffusion by several authors (Razgaities, 2003; Grandstand, 2006; Parr, 2007; WIPO/ITC, 2005, Kemmerer and Jiaqing, 2008).

Real options and Monte Carlo simulation methods

The real option method allows the separate evaluation of all the assumptions involved in a cash-flow projection, each assumption having a different level of uncertainty for which different risk-adjusted hurdle rates are defined. This is a more complex and time consuming approach, but it contributes to a more complete and exact analysis of the investment return (Soares et al, 2007). The Monte Carlo simulations are more frequently used than the real options method. The probabilistic model generates multiple scenarios regarding the profitability of the investment and the probability of attaining a predefined critical value.

Patent auctions

Patent auctions are gaining increasing importance on technology transfer processes (Ciardullo and Evans, 2006). Auctions are a quicker way of commercializing patents, provided they are of high quality (EPO, 2008). Auctions can be a way to license patents that otherwise would fall for absence of payments of patent fees, or to commercialize and define territorial extension rights of patents which are in the final stage that precedes the PCT applications stage. The planning of auction events requires a considerable organization and publicitation effort and it's not easy to have several bids for just one piece of technology (Tansik, 1991).

Evaluation methods in use and not in use by the TTUs under consideration

Checklists and pre-defined models are the most frequently used evaluation methods, which are followed by the analysis of previous agreements and cash-flows projections when there's a firm manifestation of interest or when considering the creation of a new spin-off company.

The 25% rule isn't in use, because its application isn't well understood, and because there are doubts on whether the value of 25% is adequate, since this value can vary according to the rights conceded, the patent stage of development, and the production and distribution requirements. This rule is based on an average distribution of license agreements, but because each agreement is unique the rule may cast some doubts

on its effectiveness (Speser, 2006). However, it may serve as a starting point for the negotiation process.

The real options and Monte Carlo simulation methods aren't in use because the TTUs prefer evaluation methods which allow a quick inspection of several variables, instead of analyzing whole scenarios that may affect the invention profitability. Patent auctions are also not in use, since the value of the technology relies exclusively on investor bids, where there's no space for negotiations, but they can be useful for some technologies as previously discussed, and one TTU is considering the use of this technology transfer method.

Articulation between the evaluation methods

The methods presented above can be used in different stages of the evaluation process. In a first stage, preparatory for the submission of a patent application, patent databases are extensively used, to understand the invention and the state of the art related to it, and scoring matrices and rapid report models are used to understand the invention market potential. In a second stage, usually when there's a firm manifestation of interest, the technology transfer professionals, to define the agreement payments structure and to prepare the negotiations tend to recur to comparable agreements, royalty standards, discounted cash-flow projections and some may also recur to the 25% rule, the real options and Monte Carlo simulation methods. Simultaneously to these two stages, the TTUs network of contacts is activated, in order to obtain technical and market counseling, information on investment sources, and to facilitate the access to equipments or materials external to the university which are necessary to achieve the invention proof-of-concept and proof-of-market. Contacts may also be established with potential end users of the technology. After the patent registration, auction patents may also be used, in this case the payment structure negotiation is relieved because the value is decided by the highest bid. The use of these evaluation methods will support the draft of an agreement which can be seen positively by both parties, and a balanced distribution of the gains may be achieved, although, to understand this process we also need to know the different possible payment modes that should be considered in this kind of negotiations. The next section addresses this issue.

TYPES OF PAYMENT USED IN LICENSING AGREEMENTS

The definition of the payment structure must consider different dispositions which may influence the licensing agreement value. Some of those dispositions are:

- At technology level: the invention scope, territorial rights and protection length, the level of exclusivity conceded to reproduce, modify, make further R&D or to develop new products based on

the invention, the stage of technology development, the level of complexity and the skills required to use it, its robustness to operate in different environments, its friendly use, easy and intuitive reproduction and packaging, the number of technologies that must be integrated with the invention to obtain a full commercial product, the possibility of mass production, the compatibility with existing systems, the risks and the costs inherent to future developments, and its social and environmental impact;

- At market level: the present and emergent competitive technologies, the technology strategic importance, the differentiated applications resulting from the invention and the industries envisaged, the applications market size and growth rate, the emergent and declining customer segments, the strength of existing firms and brands, the marketing, distribution and sales complexity, the applications life cycle and their revenue streams.

These are some disposition affecting the payments value, but there are other dispositions which also deserve attention, such as the rights over the improvements made with or on the technology, the possibility of sub-licensing, the payment of patent fees in several countries, the agreement length, and the exclusivity of rights granted, the inclusion of technical services, the provision of equipment or other resources from the part of the university or the firm, the existence of projects and competing R&D teams, the value of the royalties practiced in the industry and the potential gains from the technology commercialization.

All these dispositions must be considered or appraised so that the nature, the circumstances and the terms of the agreement are reflected in the payment values and in its structure, which can be divided in fourteen categories:

- Single lump sum payment or paid-up license – a single payment for a determined period of time;
- Fixed fee per sold unit or technology utilization;
- Earned royalties, running royalties or pure royalty licenses - royalties based on a percentage of sales or technology utilizations;
- Up-front payment or up-front fee;
- Minimum (annual) cash payment - minimums or minimum royalties or license maintenance fees;
- Stage payments or milestone payments;
- Option agreements and options payments;
- Royalty adjustments;
- Deferred royalty calculations;
- Late payment penalties;
- Termination fees or kill fees;
- Sub-licensing payments;
- Equity payments;
- Support payments.

An agreement may include multiple modes of payments and the above categories are not exhaustive. In the subsequent sections we address each payment type separately.

Single lump sum payment or paid-up license

This single payment, for a determined period of time, is typical in agreements whose risk is relatively small (Johnson, 2007) and they provide advantages for both parties. The TTUs administrative control and communication costs are reduced or eliminated and the firm isn't forced to expose sensitive information, and it provides to the licensor, in a single moment, a significant amount of financial resources. To determine the payment amounts, it's advisable to make a discounted cash-flow projection, to estimate the profitability of a single payment compared to a series of deferred smaller annual payments (Pressman, 2009), and to establish the amount of payment to be made, taking into account the return on investment.

Fixed fee payment

A fixed payment per sold unit or technology utilization may be established. This value must be updated every year by reference to inflation rates (Howard and Johnson, 2001; Poddar and Sinha, 2002).

Earned royalties or running royalties

Running royalties are based on a percentage of the price of the licensed product, or on a percentage of the product sales operational results. This mode of payment shares the risk between the licensor and the licensee, since the licensor receives a larger or a smaller payment depending on the sales success (Wada, 2004). The running-royalties are an important licensor signal of confidence in the invention commercialization success. (Jonhson, 2007). The running-royalties are often used when the uncertainty in forecasting the sales volume is very high and when the technology and its applications are still in an early-development stage and it's believed that the involvement of both parties can positively affect the commercialization success. To establish the royalties percentage to be paid, discounted cash-flows, the 25% rule, royalty standards, or the real options or Monte Carlo simulation methods can be used.

Up-front payment or up-front fee

An up-front payment is a payment required by the licensor whose purpose is to assure the licensee commitment in the invention commercialization success. Up-front payments are obtained in exchange for a reduction in the royalties percentage (Thalhammen-Reyero, 2008). One common rule, used on this modality, is the definition of a payment based on the estimative of the value to be obtained in a year where the project is already well under way (Razgaities,

2003). It's thus necessary to recur to discounted cash-flow projections, but the value of the up-front payment may also reflect the adequate amount that each party deems necessary to keep the project on track towards its commercial success.

Minimum cash payment

Minimum annual payments are required by the licensor for the licensee to maintain its exploitation rights. The aim is also to assure that due diligence is being taken by the licensee in the invention commercialization success (Kim and Blacklock, 2009). Its value can be established based on a conservative or optimistic scenario resulting from the sales estimative and it can correspond to one quarter or two quarters of the projected royalties for a certain year (Razgaities, 2007).

Stage payments or milestone payments

These are payments required to the licensee each time certain development or commercialization objectives or milestones are successfully attained (Wood, 2004; UMIP, 2005; Leone and Oriani, 2007), such as, the conclusion of an R&D stage, the beginning of sales or the development of a new application based on the technology.

Option agreements and options payments

An option is the right to make future decisions relative to the acquisition or exploitation of a technology. Options can be very useful for the development and validation of the technology and its market, and the investors are able to make an informed decision about the acquisition of rights. If an investor wants to conduct additional research and development, the option may include an exclusive right, and in this case, an initial payment is defined. This payment compensates the licensor for deferring its search for licensees during the time the option takes place. Options that imply exclusive rights may condition other opportunities, and in the case the option is not activated, it may affect future deals. Thus, in the option agreement, its duration must be clearly defined, as well as the obligations of each party and the consequences in case the option is not taken (Razgaities, 2003). Option agreements generally last for 6-12 months and they are very useful on the creation of new enterprises (Franko and Ionescu-Pioggia, 2006). Other options are possible, such as the option to obtain a non-exclusive license after an experimentation and testing period.

Royalty adjustments

An agreement may include the possibility of readjusting the royalties' value. A scale of reductions in the percentage of the royalties may be introduced to reflect some circumstances, like the reduction of the invention value due to new competing technologies, production

and commercialization costs higher than expected, due to the impossibility of obtaining the rights in a certain region or due to the change of an exclusive license into a non-exclusive one (UMIP, 2005). The reduction of royalties may also serve as an incentive to increase the production and the sales. The definition of a lower value of royalties, that increases if certain commercial objectives are met, are usually called, kicker royalties (WIPO/ITC, 2005), this increment scale of the royalty values may also be introduced to reflect the circumstances of a favorable reality to commercialize the invention due to the greater product absorption or due to low production costs, or other favorable commercialization events.

Deferred royalty calculations

When there's high uncertainty over the technology development results and commercial success and there's a reasonable amount of trust between the parties, it may make sense to define the royalties and other forms of payment after the technology and the market validation has occurred. When payments are set *a posteriori*, it's important to define deadlines to achieve certain results or to communicate certain objectives, so that the results can be analyzed and the payments defined according to those results. This payment type is mostly used among university spin-off firms where a relation of trust has been built and is present.

Late payment penalties

The date for each payment must be well defined in the agreement and penalties must be established in case of default, to discourage future defaults (Razgaities, 2003).

Termination fees or kill fees

A license presupposes a fixed duration. If a contract is broken, fees must be paid to the institution, to compensate for lost opportunities. This type of payment is usually used as a measure of licensees' credibility.

Sub-licensing payments

Sometimes the licensee has access to large networks and is interested in distributing the technology to third parties, which enhances its sales and liquidity. These contracts must preview how the gains will be distributed among licensors, licensees and sub-licensees. Sub-licensing is common in exclusive licensing agreements (Franko and Ionescu-Pioggia, 2006).

Equity payments

The university may opt for an equity participation in a firm, assuring financial support for the firm or technology transfer without or at reduced cost for the firm. The most successful universities in terms of technology transfer have always some form of equity in

spin-off firms and have explicit and proactive measures directed towards its development (Lockett et al, 2003). The financial return via equity participation is generally higher than the one obtained via licensing, and universities seem to be more engaged in equity if they are more experienced in technology transfer (Bray and Lee, 2000, Feldman et al, 2002).

Support payments

The licensor support in terms of technical assistance is particularly important for sophisticated technologies and during the license early years where the licensee goes through a learning curve process, and they can have a positive impact in terms of investment risk reduction, and for the licensor they are an important source of revenues and they enhance the relationship with the licensee and the possibility of establishing new commercial and investment relations.

Types of payment used by the TTUs in licensing agreements

A license agreement creates contractual obligations between the licensor and the licensee, and several modes of payment, that reflect several considerations whose nature may be economical, technological, legal or commercial, may be included on the contract. The most frequent modes of payment in use by the TTUs are the running royalties, but other modes are frequently included on technology transfer agreements, such as the up-front payments and the minimums, but there's usually a concern in assessing the firms position and there's also a concern on establishing a mutual relationship, especially when the firms have previous relations with the university or when a new firm is established to exploit an invention. This concern is also reflected on the frequency of payments established after a period of experimentation and tests (deferred royalty calculation) - some TTUs express apprehension on establishing this type of payments because of potential conflicts that posteriori payment agreements may generate. In what concerns to support payments for scientific and technical services they're quit frequent on the TTUs license agreements. These services, a mixture of maintenance and technical assistance, increase the licensor revenues, and they also have the advantage of keeping the relationship with the licensee enhancing the possibility of transferring other solutions. The grant of

sublicensing rights is also common, in what concerns to stage payments or milestone payments they're not frequent, the same happens with equity participation, single lump sum payment, option payments and termination fees. Among the types of payments not in use by any TTU are the fixed fees, the royalty adjustments and the late payments penalties.

EARNINGS DISTRIBUTION

Each university has its own rules or set of principles that define how the gains from licensing agreements is distributed within the university stakeholders. Higher fees paid to the inventors seem to be positively related to the number of inventions, to the financial return of the licenses and in the attraction of abler researchers (Lach and Schankerman, 2003) and universities tend to pay larger percentages to inventors that take the initiative to create their own spin-off firm, these higher fees are aimed to compensate the inventors initiative and risk taking attitude (Lockett et al, 2003; CEC, 2007). In what concerns to the TTUs, they typically receive 10% to 25% of the license revenues and the university tends to subsidize directly the TTU activities during several years, until it becomes self-sufficient (young, 2007). Many years can pass before self-sufficiency is attained, and the TTU must reach a balance between the resources available and what they can protect. As a rule of thumb, only one in ten invention disclosures' is patentable, and only one in ten patents is licensable (Dodds and Somersalo, 2007). Evaluation practices are thus essential in the process of decision making regarding patents and in the marketing and licensing of inventions.

The distribution of licensing agreements revenues among the inventors within the universities at study range from 30% to 60% and, these universities, do not specify the earnings distribution among their TTU and when a new spin-off firm is created by university personnel. The remaining earnings are used to support the research centre where the invention took place, to acquire equipment and materials and to make further research work on the technology having in mind future gains. Revenues are also used in transversal activities, mainly in the management and reinforcement of intellectual property rights and in the development of strategic R&D projects.

Tabel 2: Structure of earnings distribution within the universities involved on this study

University	Earnings distribution
University of Aveiro (Universidade de Aveiro)	40% for inventors 60% for the University (negotiable)
University of Beira Interior (Universidade da Beira Interior)	55% for inventors 45% for the University, of which 25% for the Department or Centre 20% for the Central Executive Services
University of Coimbra (Universidade de Coimbra)	55% for inventors 45% for the University, of which

	30% for the Faculty 15% for the Central Executive Services
University of Minho (Universidade do Minho)	45% for inventors 45% for the University, of which 15% for the Department or Centre 15% for the Faculty 15% for the Central Executive Services 10% for remuneration of risk capital (central services)
New University of Lisbon (Universidade Nova de Lisboa)	30% - 55% for inventors, depending on the profitability Remaining for the University, to be distributed by the departments, on a case by case manner
University of Porto (Universidade do Porto)	60% for inventors 45% for the University, of which 30% for the Faculty or Department or Centre 10% for the Central Executive Services
Technical University of Lisbon (Universidade Técnica de Lisboa)	50% for inventors 50% for the University

CONCLUSIONS AND FURTHER RESEARCH

To understand and improve the information and knowledge about technology evaluation and licensing methods and strategies this paper has formulated a series of research questions allowing the identification and description of technology valuation practices in use by university technology transfer units.

From the empirical results obtained several conclusions could be reached. The following is a summary of some important ones, grouped according to the main concepts developed on this paper:

Selectivity on patent protection

- The size of the patent portfolio is not directly related to the number of licensing agreements;
- Different degrees of selectivity in terms of patent protection are assumed:
 - The less selective TTUs seek to increase the number of patents to motivate the researchers' productivity and their culture and experience on writing patent applications.
 - The more selective TTUs devote more time and resources on a smaller number of high-potential inventions and they prefer to patent by making a previous estimation of future patent and management costs to protect future dividends and to avoid copy and they also take into account the probability of finding suitable partners; others are selective only when considering the expansion of the patent rights on a geographical scope.

Origin of technology transfer agreements

- The majority of the university-industry relations are established through the inventors and TTUs informal networks;
- Informal networks have an important role in assessing the invention technical and market potential, on the identification of suitable partners and funding sources, on the support to new spin-off firms, on the identification of the geographical

scope for patent protection and on the definition of new product innovation strategies;

- The development of tailor-made technology according to the firms requisites is one of the main sources of licensing agreements (these projects arise either by the firms, the TTUs or the researchers to solve specific problems and to take advantage of programs supporting R&D activities), other sources are the contact with Portuguese firms of national dimension knowing that the international contacts are assuming increasing importance, the prior industry connections and the inventors engagement and predisposition to create a company;
- The existence of an integrated management of the IPR protection, entrepreneurship and licensing activities improves the relationship between the TTUs and the researchers and the definition of commercialization strategies;
- The existence of a structured management to monitor the development of projects since their inception until their diffusion can have a positive impact on the attainment of transferable patents and on the reduction of costs and time to accomplish the project desired results, this structured management is also meant to articulate the particular characteristics of one project with the needs and interests of the firms economical development;
- The effective internal and external communication is what's behind the growth and success of the universities technology transfer units;
- Many patents were licensed not because they embedded an innovative technology, but because there was a complete product, which included a patent, whose functionalities were demonstrated on the ground;
- TTUs also seek firms that commercialize similar and predecessor solutions as a faster route to commercialize the university intellectual property rights;
- The countries with which there are more licensing agreements are the Portuguese speaking countries,

including Macau, but specially Angola, and the countries of Eastern and Mediterranean Europe, including Turkey, but many other agreements have been established with other countries such as the United States of America and many of the European countries;

- The TTUs general perception of a good partner is that it has the adequate technological capacities and competencies to further develop the technology and to initiate a large scale production, that has access to the networks that are necessary to address the relevant markets and, above all, is a credible partner, that respects deadlines and meets the defined targets and that negotiates fairly so that each partner feels that a balanced agreement is reached.

Obstacles to technology transfer

- Main limitations are associated with the difficulty on finding partners with adequate technological and marketing capacities, with cost uncertainties, with the technology development stage and with the time required to obtain solutions with the required industrial specifications;
- The lack of a national proof of concept fund is a weakness remarked by the majority of the university technology transfer units.

Technology evaluation methods

- Checklists and pre-defined evaluation models are the most widely used instruments on the evaluation of invention disclosures;
- Previous agreements and discounted cash-flow projections are mainly used when a spin-off firm is under consideration or when the TTUs receive an investor manifestation of interest;
- Royalty standards are also in use by a few TTUs to know the payments value range in certain industrial sectors to plan their negotiations with potential licensors;
- Invention comparative analysis and positioning against existent solutions that may overlap on its purpose without having the same characteristics is one of the main evaluation methods in use by the TTUs specially when considering incremental technical solutions.

Payment structure

- The more frequent modes of payment are the running royalties, but other modes are frequently included in the technology transfer agreements, such as the up-front payments and the minimums;
- Payment for scientific and technical support services increase the licensor revenues and they have the advantage of keeping the relationship with the licensee enhancing the possibility of transferring other solutions;

- Deferred payment calculations are in use especially when the firm has previous relations with the university or when a new spin-off firm is established to exploit an invention. Some TTUs express apprehension on establishing this type of payments because of potential conflicts which can be generated;
- With regard to the investment on new spin-off firms social capital we have noticed a lack of University technology transfer units on this engagement process, which does not mean a lack of participation by other university units that may be happening. We should remember that according to our literature review the participation on spin-off firms usually has a higher investment return than the own usually obtained with a licensing agreement (Bray and Lee, 2000, Feldman et al, 2002).

Earnings distribution

- Revenues from licensing agreements are mainly used to reward the researcher or research team who produced the invention and to support their unit of affiliation;
- Allocation of revenues to the inventors differs from university to university and has a range from 30 to 60 percent of the total revenues;
- University rules at study do not specify the allocation of revenues for the TTUs, nor do they specify the distribution of revenues when a new spin-off firm is created, knowing that universities tend to pay larger percentages to inventors who take the initiative to create their own spin-off firm as a means to compensate their initiative and risk taking attitude (Lockett et al, 2003; CEC, 2007).

It also came clear from these study that there is the need to create a regular communication process between the TTUs so that each unit can be aware of the practices of the others and learn with each other experiences by identifying successful actions and possible errors and areas where improvements can or should be done. In consonance with this technology transfer coordinated and planned approach which enables the replication, validation and follow-on innovation we can affirm that only knowing the economic value of an invention can we fully exploit its full potential and can we carry out an appropriate technology valorization strategy.

Outline of further research

The following research lines are examples of the need to deepen the problematic of technology evaluation and licensing, and to address some unanswered issues that came out of this articulation between the literature review and knowledge acquired in contact with the Portuguese university technology transfer units.

- Commercialization of inventions in the global market: indexes of geographical market penetration and the cost-benefit relation of technology licensing agreements developed by universities;
- Competitive watch and the university scientific and technological productivity: R&D centers practices and the TTUs contribution to identify and spread research lines and business opportunities;
- The technological production utility: the correlation between technology licensing and its impact on the research teams development, visibility, reputation and social and economical reward.

These research lines create the opportunity to better understand the application of technology evaluation and licensing practices, and to capture the meanings that lie in the evaluation and innovation procedures implemented by technology transfer professionals.

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ON THE MULTI-MODE, MULTI-SKILL RESOURCE CONSTRAINED PROJECT SCHEDULING PROBLEM – COMPUTATIONAL RESULTS

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ABSTRACT

This paper is concerned with an extension of the Resource-Constrained Project Scheduling Problem (RCPSP) which belongs to the class of the optimization scheduling problems with multi-level (or multi-mode) activities. We developed a practical tool, useful to represent multi-mode projects, and to find a solution for the problem on hand – select the best mode for each resource in each activity in order to minimize the total cost, considering the resource cost, a penalty for tardiness and a bonus for early completion. We implemented an adaptation of a filtered beam search (FBS) algorithm to this problem, using the C# programming language. A “filtered beam” search is a heuristic Branch and Bound (BaB) procedure that uses breadth first search but only the top “best” nodes are kept. We give some of the most important solution details and we report on further computational results, by testing the application for different problem sizes.

INTRODUCTION

The resource-constrained project scheduling problem (RCPSP) has been demonstrated to be in the class of NP-hard problems (Blazewicz et al. 1983). The need to solve real problems in reasonable time led researchers to develop heuristic procedures.

The heuristics being used belong to one of two classes: the class of priority rule-based methods or the class of meta-heuristics approaches. The priority rule-based methods build a plan by selecting activities from a range of activities available successively so that all activities are sequenced (Boctor, 1993; Dean et al. 1992; Heilmann, 2001). The meta-heuristics based methods begin with an initial solution and try to improve it. The improvement of a solution is obtained by transforming one or several solutions into new ones. There are still two types of heuristics, series heuristics where the priority of the activities is predetermined and remains fixed, and parallel heuristics where the priority is updated each time an activity is scheduled for processing.

Another type of heuristics found in the literature, are sub-fields of meta-heuristics such as tabu search, simulated annealing (Mika et al., 2005) and genetic algorithms. Gonçalves et al. (2004) presented a genetic algorithm for the RCPSP problem. They used a chromosome representation based on random keys. Tseng (2008) also discussed the use of genetic algorithms applied to the multi-project, multi-mode RCPS problems (MMRCMPSP).

It is also usual to find integer programming models applied to single and multi-project environments. Multi-project problems are indirectly analyzed using single project procedures and considering the parallel projects as parallel sequences of activities with the same start and end nodes.

The profusion of binary variables and constraints has led researchers to develop branch-and-bound (BaB) procedures for the problem. The success of this technique depends on the branching technique and on the tightness of its lower limit.

Kis (2005) concentrates on the scheduling problem where the need for resources for each activity varies in proportion to the intensity of the activity itself. To formalize the problem he used an integer linear programming model and proposed a BaB algorithm to find the optimal solution. However BaB procedures are inadequate for real size problems despite their efficiency relative to a frontal attack on the discrete optimization problem.

Another recent paradigm is the Electromagnetism-like Mechanism (EM). Tereso et al. (2004b) presented an application of the EM to stochastic multimodal projects that had been studied before using Dynamic Programming (DP) (Tereso et al., 2004a). The DP model was developed later on a distributed platform (Tereso et al., 2006). Improved results of the EM, in terms of computing performance, with an enhanced application using JAVA, were also obtained (Tereso et al., 2007).

In the several resource constrained scheduling problem models found in the literature, there are two important elements: the objective function and the constraints. Constraints complicate the efficient optimization of problems, and the more accurately they describe the real problem, the more difficult it is to handle. Willis (1985) described requirements for modeling realistic resources.

These requirements include the variable need of resources according to the duration of the activity, variable availability of resources over the period of the project and different operational modes for the activities. A discrete time/resource function implies the representation of an activity in different modes of operation. Each mode of operation has its own duration and amount of renewable and non renewable resource requirements.

Boctor (1993) presented a heuristic procedure for the scheduling of non-preemptive resource-limited projects, when the resources are renewable over time. Each activity had a set of possible durations and resource requirements. The objective was to minimize the project duration. A general framework to solve large-scale problems was suggested. The heuristic rules that can be used in this framework were evaluated, and a strategy to solve these problems efficiently was designed. Heilmann (2001) also worked with the multi-mode case in order to minimize the duration of the project. In his work, besides the different modes of execution of each activity, there is specified a maximum and minimum delay between activities. He presented a priority rule-based heuristic. The problem presented here also belongs to the class of the optimization scheduling problems with multi-level (or multi-mode) activities; i.e., the activities can be scheduled in different modes, each mode using a different resource level/skill, implying different costs and durations.

The objective may be based on time, such as minimize the project duration (Boctor, 1993; Heilmann, 2001; Basnet et al., 2001; Guldemon et al., 2008) or on economic aspects, such as minimize the project cost (Mika et al., 2005; Tereso et al., 2004a; Tereso et al., 2006). However, success relative to time does not imply success in economic terms. A recurrent situation encountered in practice is the need to complete a project by its due date and maximize profit. Özdamar and Ulusoy (1995) reported in their survey of the literature, studies where the NPV is maximized while the due date is a 'hard' constraint (Patterson et al., 1989, 1990). As the costs depend on the activities in progress and scheduling is related to other constraints than monetary, the researchers explicitly included cash-flows-resources-constraints in their formulations. Elmaghraby and Herroelen (1990) lay down the following property of an optimal solution that maximizes the NPV: the activities with positive cash flows should be scheduled as soon as possible and those with negative cash flow as late as possible. They concluded that the earlier conclusion of the project is not necessarily the optimal solution with

regard to maximizing the NPV. In Mika et al. (2005) study, a positive flow is associated with each activity. The objective was to maximize the NPV of all cash flows of the project.

Problem description

Consider a project network in the activity-on-arc (AoA) mode of representation: $G = (N, A)$, with $|N| = n$ (representing the events) and $|A| = m$ (representing the activities). Each activity may require the simultaneous use of several resources with different resource consumption according to the selected execution mode. An activity may be initiated as soon as it is sequence-feasible, subject to resources availability. There are $|R|=p$ resources. A resource has a capacity of several units (say w workers or m/c 's) and may be used at different levels, such as a resource of electricians of different skill levels, or a resource of milling machines but of different capacities and ages. A level may also be the amount of hours used by a resource; for example, half-time, normal time or over-time. The processing time of an activity is given by the maximum of the durations that would result from a specific allocation of resources. Each activity must be allocated exactly one unit of each required resource and the resource unit may be used at any of its stated levels. The objective is to determine the optimal allocation of the resources to the activities that minimizes the total project cost (resources + penalty for tardiness + bonus for earliness), while respecting a delivery date. Briefly, the constraints of this problem are:

- a) Respect the precedence among the activities.
- b) A unit of the resource is allocated to at most one activity at any time at a particular level.
- c) Respect the capacity of the resource availability.
- d) An activity can be started only when it is sequence-feasible and all the requisite resources are available, each perhaps at its own level, and must continue at the same resources levels without interruption or preemption.

In a previous paper we provided a formal model to the multi-mode, multi-skill resource constrained project scheduling problem (MRCPSP-MS) (Figure 1) and a breadth-first procedure description (Santos and Tereso, 2010a).

Let:

- $G(N,A)$: Project network in AoA representation, with a set of N nodes, representing the events and A activities.
- n : number of nodes; $n = |N|$.
- m : number of arcs or number of activities; $m = |A|$.
- a : activity, which may also be represented by arc (i,j) .
- r : resource $r \in |R|$
- C^k : the k th uniformly directed cutset (*udc*) of the project network that is traversed by the project progression; $k = 1, \dots, K$.
- l : level at which a resource is applied to an activity.
- $x_{(a,r,l)}$: a binary variable, of value 1 if resource r is allocated to activity a at level l , and 0 otherwise.
- $p(a,r,l)$: the processing time of activity a when resource r is allocated at level l .
- $p(a)$: processing time of the activity a (considering all resources).
- $c(a,r,l)$: resource cost of activity a when resource r is allocated at level l .
- $c_R(a)$: resource cost of the activity a (considering all resources).
- η_a : the count of resources required by activity a .
- ρ : number of resources, $\rho = |R|$.
- b_r : capacity of resource r .
- $\gamma(r,l)$: marginal cost of resource r at level l .
- γ_E : marginal gain from early completion of the project.
- γ_L : marginal loss (penalty) from late completion of the project.
- t_i : time of realization of node i (AoA representation), where node 1 is the "start node" of the project and node n its "end node".
- T_s : target completion time of the project.
- c_E : earliness cost.
- c_T : tardiness cost.
- c_{ET} : earliness-tardiness cost.
- c_R : total resource cost for all project activities.
- TC : total cost of the project.

Minimize TC

Subject to:

$$p(a) \geq p(a,r,l) \text{ for all } a, r \text{ and } l$$

$$t_j - t_i \geq p(a), \forall a \in A$$

$$\sum_{a \in C^k} x_{(a,r,l)} \leq b_r, \forall r \in R$$

$$\sum_{\text{for all } l} x_{(a,r,l)} = 1, \forall a, \forall r \in R$$

$$\eta_a - \sum_{r \in R} \sum_{\text{for all } l} x_{(a,r,l)} = 0, \forall a \in C^K$$

Where:

$$TC = c_R + c_{ET}$$

$$c_R = \sum_{a \in A} c_R(a)$$

$$c_{ET} = c_E + c_T = \gamma_E \cdot e + \gamma_L \cdot d$$

$$c_R(a) = \sum_{r \in R} c(a,r,l)$$

$$c(a,r,l) = \gamma(r,l) * p(a,r,l)$$

$$e \geq T_s - t_n$$

$$d \geq t_n - T_s$$

$$e, d \geq 0$$

Figure 1: Mathematical Model

Then in Santos and Tereso (2010b) we presented an adaptation of a filtered beam search (FBS) algorithm to this problem, using C# programming language and reported on the preliminary results obtained for small project networks. The application developed allowed determining the project solution using either the Breadth First Search (BFS) algorithm or the Beam Search Algorithm procedure. In this paper we report on further computational results, by testing the application for different problem sizes.

SOLUTION DETAILS

In the BFS algorithm, all the nodes (partial solutions) in the search tree are evaluated at each stage before going any deeper, subsequently realizing an exhaustive search that visits all nodes of the search tree. The branch and bound (BaB) search technique can be seen as a polished BFS, since it applies some criteria in order to reduce the BFS complexity. The BaB process consists of two procedures: subset generation and subset elimination. The former (the subset generation) is accomplished by *branching*, where a set of descendent nodes are generated, creating a tree-like structure. The latter (subset elimination) is realized through either *bounding*, where upper and lower bounds are evaluated for the "value" of each node, or *feasibility*, where the extension of a partial solution is deemed infeasible, and the branch is aborted. The bounding function can be strong, which is usually harder to calculate but faster in finding the optimal solution, or weak, which is easier to calculate but slower in finding the solution. The BaB approach is more efficient if the bounds can be made very tight. In

our case, the objective of our problem is to minimize the total cost of the project (which includes a bonus for early completion or a penalty for exceeding the specified due date). As a result, finding a strong bounding function would depend on the three project parameters cited: the penalty cost, the bonus cost and the due date. A FBS is a heuristic BaB procedure that uses BFS but only the top "best nodes" are kept. At each stage of the tree, it generates all successors for the selected nodes at the current stage, but stores only a preset number of descendent nodes at each stage, called the *beam width*. Basnet et al. (2001) presented a FBS approach to generate makespan-minimizing schedules, for multi-mode single resource constrained projects, where there is a single renewable resource to consider and the multi-mode consists basically of how many people can be employed to finish an activity.

The BaB and the Beam Search procedures are typical methods applied to the RCPSP (Basnet et al., 2001; Demeulemeester and Herroelen, 1996; Kis, 2005). The differentiating aspects of our approach are, first, the definition of a set of states defined by the condition of the activities, combined with the priority rules used to solve resource conflicts, and second, the alternative evaluation rules used to discard "undesirable branches".

Procedure description

The procedure to be executed can be based either on the BFS algorithm or on the Filtered Beam Search algorithm. If the latter is the one adopted a beam width value must be defined. We consider that activities can be in one of four states: "*to begin*", "*pending*", "*active*"

(i.e., on-going) and “*finished*”. To get the first activities with which to initiate the process, we search all activities that do not have any predecessors. These activities are set to state “*to begin*”. All others are set to the state “*pending*”.

Activities in the state “*to begin*” are analyzed in order to check resources availability. If we have enough resources, all activities in the state “*to begin*” are modified to the state “*active*”; otherwise we apply, in sequence, the following rules, until resources conflict are resolved:

1. Give priority to activities that are precedents to a larger number of “*pending*” activities.
2. Give priority to activities that use fewer resources.
3. Give priority to activities in sequence of arrival to the state “*to begin*”.

An “event” represents the starting time of one or more activities, and the project begins at event 0 in which no activity has started yet. Each activity must be allocated exactly one unit of each resource. For each *active* activity, we calculate all the possible combinations of resources levels. Then we join all activities combinations, getting the initial combinations of allocation modes for all “*active*” activities. These initial combinations form branches through which we will get possible solutions for the project. All combinations have a copy of the resources availability information, and activities’ current state.

If the algorithm selected to find the best solution is the Beam Search Algorithm, then:

1. If the number of combinations is less than the beam width value, all combinations are kept.
2. Otherwise, the set of combinations must be reduced to the beam width value. In this case some combinations need to be discarded using the possible rules to evaluate the ones in the top best:

Select the top best combinations that have:

- Minimum Duration.
- Minimum Cost.
- Minimum Cost/Duration.

Not all combinations of the set can be directly compared, because the number of activities that have been scheduled in each combination may differ. So the combinations are grouped by the number of activities that have been already schedule.

Then the combinations are compared with the others that belong to the same group. The final set is composed by a share of combinations of each group formed before.

The ratio of each group in the final combinations set is calculated by:

$$ratio = groupCount / totalCombinations \quad (1)$$

In either case, we continue applying the following procedure to each combination:

3. To all activities in progress, we find the ones that will be finished first, and set that time as the next event.

4. We update activities found in step 1 to state “*finished*”, and release all the resources being used by them.

5. For all activities in the state “*to begin*”, we seek the ones that can begin, the same way we did when initiating the project. Activities in the state “*to begin*” are analyzed in order to check resources availability. If no resource conflicts exists, all activities in the state “*to begin*” are set to state “*active*” and resources are set as being used, otherwise we apply in sequence, the rules described above.

6. For all activities in the state “*pending*”, we check for precedence relationships. For all activities that are precedence-feasible their state is updated to state “*to begin*”. These activities are not combined with the previous set of “*to begin*” activities to give priority to activities that entered first in this state.

7. If there are resources available and any pending activities were set “*to begin*” we apply step 5 again.

8. For all new “*active*” activities we set their start time to the next event found in step 3, and determine all the possible combinations of its resource levels. Then we join all found combinations for these activities, getting new combinations to add to the actual combination being analyzed. This forms new branches to the process in order to get the project solution.

9. We continue by applying step 1 (or 3) to each new combination until all activities are set to state “*finished*”, at which time we have a valid project solution.

When the project final solutions are found, we evaluate for each alternative the finishing time of the project and the total project cost, choosing the best one.

Application Development

Three main classes were defined for the application. The base *class* is *NetProject* that keeps all project required information: name, activities, resources, due date, bonus and penalty cost. Then we have the *Resource class* that keeps the resource identification availability and levels. Each resource level has a unitary cost. The *Activity class* has activity identification, resources requirement and its precedents. These classes are the most relevant to represent the project. Additional classes are used to support the evaluation of the project solution.

To construct the project network (in AoN), we use Graph#, an open source library for .Net/WPF applications that is based on a previous library QuickGraph. These libraries support GraphML that is an XML-based file format for graphs, although we didn’t make use of this format. The graph is automatically generated for each project loaded in the application. To save/load existing projects we define an xml file that embodies all project characteristics for this problem. The application provides the functionalities described next.

- Load a Project.
The project must be saved as an xml file, using a structure that represents the project components (activities, resources, etc.).
- Create a Project:
There are two main steps to create a new project:
 1. First the project “skeleton” is built through a wizard that initiates asking the project name and the number of resources and activities. Next the resource data is introduced namely the availability of each resource and the number of associated levels. Finally the activities information is introduced namely the identification and precedents of each activity.
 2. Secondly it generates the project graph and a project grid where the remaining project information can be introduced.
- Edit/Save a Project.
- Determinate best solution:
This can be achieved using a Breadth First Search based Algorithm or a Beam Search Algorithm.
- Save solution to a txt file.

Figure 2 shows the application appearance:

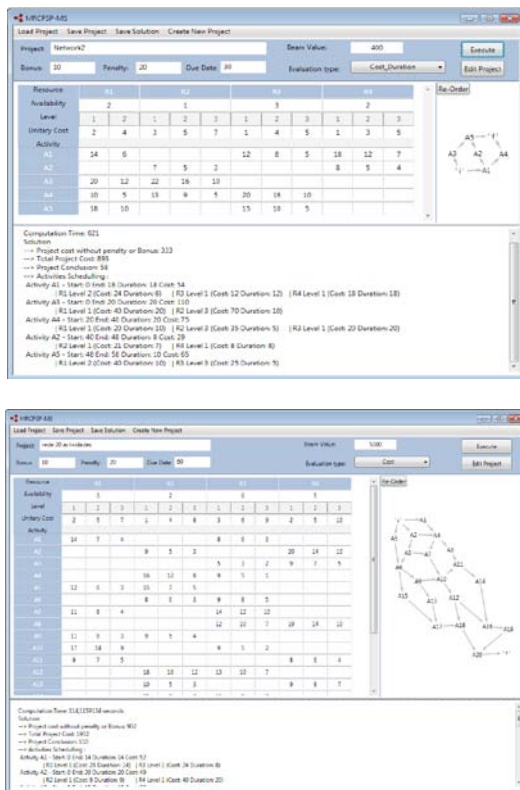


Figure 2: Application appearance

COMPUTATIONAL RESULTS

The following computational tests were performed on an Intel® Pentium® M @1.20GHz 1.25GB RAM.

Consider a three activities network, using 4 resources, one with 2 levels and the others with 3 different levels respectively. Assume the following rates for earliness and lateness costs: $\gamma_E = -10$, $\gamma_L = 20$ and the due date $T_S = 24$.

Table 1: Three activities network solution totals, obtained using BFS Algorithm.

t_n	C_E	C_T	C_R	TC	Runtime (s)
16,0	80,0	0,0	230	150,0	0,66

Table 2: Three activities network solution totals, obtained using Beam Search Algorithm.

Beam Width	Evaluation Type											
	Cost						Duration			Cost/Duration		
	t_n	C_E	C_T	C_R	TC	Runtime (s)	t_n	C_E	C_T	C_R	TC	Runtime (s)
150	26	0	40	201	241	0,33	16	80	0	230	150	0,05
200	26	0	40	201	241	0,48	16	80	0	230	150	0,06
700	20	0	40	201	241	0,25	16	80	0	230	150	0,03
900	16	80	0	231	151	0,42	16	80	0	231	151	0,60

The BFS Algorithm generates 972 combinations for the three activity network. We try to use a beam width between 150 and 900. As we can see by the results exhibited in table 2, the *Duration* evaluation type was the best for this network, achieving the same result as the BFS Algorithm, even for the smaller beam width. The other two evaluation types gave the same result.

Consider a five activities network, using the same resources of the three activities network above. Assume the following rates for earliness and lateness costs: $\gamma_E = -10$, $\gamma_L = 20$ and the due date $T_S = 30$.

Table 3: Five activities network solution totals, obtained using BFS Algorithm.

t_n	C_E	C_T	C_R	TC	Runtime (s)
36,0	0,0	120,0	400	520,0	13,6

Table 4: Five activities network solution totals, obtained using Beam Search Algorithm.

Beam Width	Evaluation Type																	
	Cost						Duration						Cost/Duration					
	t _n	C _E	C _T	C _R	TC	Runtime (s)	t _n	C _E	C _T	C _R	TC	Runtime (s)	t _n	C _E	C _T	C _R	TC	Runtime (s)
100000	36	0	0	120	401	521	34.3	36	120	400	520	39.0	36	0	120	401	521	38.1
50000	44	0	0	280	385	665	13.0	36	120	400	520	17.4	44	0	280	385	665	13.2
10000	47	0	0	340	366	706	0.65	36	120	413	533	0.58	47	0	340	386	726	0.71
150	53	0	0	440	384	844	0.09	36	120	413	533	0.11	49	0	380	366	746	0.36

The BFS Algorithm generates 104976 combinations for the five activity network. We tried to use a beam width between 150 and 100000. As we can see by the results exhibited in Table 4, the *Duration* evaluation type achieved quicker results similar to the ones obtained with the BFS Algorithm. The other evaluation types are far from the solution obtained with the BFS algorithm using lowest beam widths, but achieve better C_R (project cost without bonus or penalty) values.

Now consider a ten activities network, using 5 different resources, three of them with 2 possible levels, one having 5 levels and the left one with 3 elective levels. Assume the following rates for earliness and lateness costs: , $\gamma_E = -15$, $\gamma_L = 20$ and the due date $T_S = 30$.

The BFS solution couldn't be achieved in a reasonable time.

Table 5: Ten activities network solution totals, obtained using Beam Search Algorithm.

	Beam Width	Evaluation Type																	
		Cost					Duration					Cost/Duration							
		t_n	C_E	C_T	C_R	TC	Runtime (\$)	t_n	C_E	C_T	C_R	TC	Runtime (\$)	t_n	C_E	C_T	C_R	TC	Runtime (\$)
50000	27	45	0	405	360	175.53	23	105	0	480	375	2114.3	42	0	120	451	691	179.1	
30000	27	45	0	417	372	95.5	23	105	0	482	377	106.52	44	0	280	440	720	88.38	
10000	27	45	0	417	372	30.53	24	90	0	491	401	42.31	44	0	280	440	720	30.29	
5000	27	45	0	417	372	13.99	26	60	0	468	408	18.37	44	0	280	447	727	19.46	
1000	29	15	0	406	391	6.35	26	60	0	468	408	7.39	45	0	300	444	744	4.47	

We observe a performance decrease in runtime values. The evaluation type *Cost* provides the best solutions, with a TC = 360 for a beam width of 50000. Using *Duration* we achieve reasonable solutions, on the other hand using the *Cost/Duration* evaluation type provide “weak” solutions.

For a twenty activities network, using the 4 resources with 3 different levels each, we have assumed the following rates for earliness and lateness costs: $\gamma_E = -10$, $\gamma_L = 20$ and the due date $T_S = 60$.

Table 6: Twenty activities network solution totals, obtained using Beam Search Algorithm.

	Beam Width	Evaluation Type									
		Cost					Duration				
3000	114	115	115	125		500					
	0	0	0	0		1000					
1080	1080	1200	1200	1300		2000					
916	916	885	885	864							
1996	1996	2005	2005	2164							
21.78	21.78	12.34	12.34	2.3							
69	69	69	69	69							
0	0	0	0	0							
180	180	180	180	180							
1519	1519	1519	1519	1609							
1699	1699	1699	1699	1789							
60.2	60.2	89.1	31	20.5							
131	131	126	132	132							
0	0	0	0	0							
1000	1000	1320	1440	1440							
896	896	868	879	879							
2316	2316	2188	2319	2319							
22.4	22.4	17.5	10.0	4.3							

The performance executing this network for large beam width was too slow. We present solutions for a beam width of 500 and 3000. Again the evaluation type Cost/Duration gave the weakest solutions, and the Duration evaluation type achieved the better ones (TC =1699, t_n =69).

CONCLUSIONS AND FURTHER RESEARCH

The experiments done for the specific networks have shown that the tool provides feasible solutions, although it doesn't guarantee the optimum. Three evaluation types are available for the beam search procedure. For the tests run so far, the better solutions are achieved using the *Cost* evaluation type or *Duration* evaluation type. The *Cost/Duration* evaluation might be discarded or remodeled. The performance of the evaluation type is influenced by the specifications of the project, like bonus/penalty costs and due dates. The machine where the tests were run is obsolete nowadays (in terms of processor and in terms of memory capacity). For larger beam widths and larger networks, the runtimes obtained are several minutes. For most projects we obtained at least 12 solutions (some equal), with reasonable total project costs (TC) and due dates (t_n).

The algorithm and the code implemented should be revised and studied, in order to introduce performance

improvements. The creation of networks for the experiments is not easy using the project creation wizard of the application, since it is necessary for the user to introduce all project data, including resources data and activities characteristics, like resources required and precedents. In the future it will be useful to have a method to generate partially (or completely) valid networks in an automatic way, and run the experiments on powerful machines. Some enhanced techniques in terms of software design can be considered to improve the program implemented.

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ADDRESSING SUSTAINABILITY: COMPREHENSIVE FRAMEWORKS FOR EVALUATING NEW PRODUCT DEVELOPMENT

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Sustainability, Systems Engineering, New Product Development

ABSTRACT

The development and commercialization of novel sophisticated products, exerts a significant burden on the environment, throughout its life-cycle. Moreover, the environmental impact also generates a significant impact onto the socio-economic dimensions. Therefore, it is imperative to include criteria for addressing socio-economic and environmental sustainability. Previously developed approaches for sustainability evaluation, were comprehensive, resource intensive and lacked simplicity. The proposed framework for Sustainable New Product Development, utilizes a Systems Engineering Approach based on multi-criteria analysis. The investigation also proposes two capital budgeting based methods for evaluation, namely NPV@Sustainability and Profitability Index@Sustainability using Life Cycle Assessment. These evaluation methods express the financial cash flows in accordance with the impact associated with the sustainability criteria and the core project milestones of the product development endeavor. The evaluation methods, together with the product development framework, are applicable during key decision points of Stage 2 and 3, in the Stage-Gate Process of New Product Development.

INTRODUCTION

The irreversible (or less reversible) consumption of resources for constantly evolving industrialization, challenges the frontiers of both technology and business management. Thus, making it imperative to consider the criteria for socio-economic (including financial analysis) and environmental sustainability (Ehrenfeld, 1994). Moreover, sustainability consideration promotes, long term strategic business advantages (Jelinski et al., 1992). The turning point in the global sensitization towards sustainability was achieved through a 1987 published report by the United Nations World Commission, titled *Our Common Future* on Environment and Development (WCED). Moreover, well-informed citizens have exerted a “market”, “incentives” and “policy” pressure onto corporations, to pursue the development of more sustainable products

(O'Brien, 2003; Xu and Morrison, 2005). Organizations committed to sustainability, encounter significant challenges, while considering several elements (namely parameters, drivers, indicators and criteria), during the design phase. The design phase is critical in dictating the fate of every product development process. Moreover, businesses have always utilized diverse and non-integrated methodologies for both design and assessment (financial and non-financial) (Loch and Kavadias, 2007; Davis, 2002; Sutcliffe et al., 2009; Daly and Cobb, 1989). However, these methodologies have proven to be inadequate and complex in addressing the overall sustainability.

The proposed New Product Development Framework provides an integrated approach towards, both product development and evaluation. The framework utilizes systems engineering approach based on multicriteria analysis. The framework, mainly intends to promote reduced number of assessment/design iterations and minimize the associated opportunity cost. Moreover, the devised project evaluation methodologies, namely NPV@Sustainability and Profitability Index@Sustainability using Life Cycle Assessment, through their systemic thinking abilities, act as supplements to the product development framework, for addressing any arising conflicts and synergies (Hacking and Guthrie, 2003).

THEORITICAL BACKGROUND

The major hurdle encountered, while addressing sustainability, is the accounting and monitoring of each consideration, that propagates from every element of the product development activities, to every other element outside its scope. This includes, but not limited to the components procurement, labour conditions and the direct/indirect impact on their socio-economic status (Charter, 1998; Brent and Labuschagne, 2004). Therefore, this study limits the sustainability considerations to only a certain pertinent, yet comprehensive set, that share a tangible relationship with the product development activities.

Approaches to address Sustainability

Since the mid 1990s, the engineering, management and scientific community have articulated sustainable environment considerations together with sustainable

societal practices, in order to address economic sustainability (Sutcliffe et al., 2009):

- a) 'Deep Green' (Sadler, 1999);
- b) The 'Triple Bottom Line' (TBL) (Pope et al., 2004);
- c) Four part frameworks, introduces the dimension of "institutional" to the already existing domains (Guijt and Moiseev, 2001).

In order to assess sustainability, the following methodologies are considered in this investigation (Sutcliffe et al., 2009):

- a) Multi Criteria Analysis (MCA) utilizes a Analytical Hierarchy Process (AHP) (Saaty, 2008) to represent the criteria (and sub criteria) arranged in a systematic multilevel hierarchy, that promotes a comparison oriented judgment, for assigning priorities at each level.
- b) Life Cycle Assessment (LCA) addresses the environmental impacts of the entire industrial life cycle and all its associated elements pertinent to every product development process (Azapagic and Perdan, 2004; Sutcliffe et al., 2009; Hauschild et al., 2007). LCA is performed as an iterative exercise, for every essential developmental phase. Each iteration reduces the uncertainty to sufficiently address questions pertaining to the Goal and Scope definition (Hauschild et al., 2007).

However, despite the promising potential of LCA tools, Yang (2007) concluded that the implementation of these tools in real-world product innovations, has not been successful for any broad adoption scenario.

Systems Engineering and Sustainable Product Development

Systems Engineering is a widely accepted approach, that can assert the risks and challenges faced during sub-system development, that are encountered during integrated systems development (Buede, 1999). Similarly, Hager (2007) and Edwards (2008) recommend the inclusion of the needs of the stakeholders, in the front-end of the development plan, in order to minimize capital-intensive modifications and failures.

Furthermore, using Systems Engineering approach, both the Project and Product Life Cycles can be entirely mapped in the Profitability Index@Sustainability Life Cycle Assessment methodology (Figure 4). These two categories intersect at multiple points, enabling the decision makers to obtain a holistic view of the complete Product Development and Commercialization Process (Brent and Labuschagne, 2004). Moreover, the holistic approach encourages innovation to devise novel and efficient processes (Gonçalves et al., 2009; Brent and Labuschagne, 2004).

The financial considerations of the impact on Sustainability is based on a modified version of capital budgeting methodologies, to address the complex nexus between the potential uncertainties and their risks (Davis, 2002; Shapiro, 2001; More and Little, 1980; Petrie et al., 2001).

NEW PRODUCT DEVELOPMENT FRAMEWORK

Figure 1 is a comprehensive representation of the broadly classified and diverse management related activities. This framework also includes, reliable and regulatory compliance. The proposed methodology is based on a combination of the models proposed by Deshmukh and Chitke (1980) and Krishnan and Ulrich (2001).

The rectangular box of R&D activities in Figure 1, is further expanded and exhibited in Figure 2, in the form of a hierarchical and multicriteria framework. The outer most oval represents successful marketable and sustainable end-of life products. The second inner oval represents the design processes associated with the end-of-life activities: DfD (Disassembling), DfS (Maintenance), DfM (Manufacturing), DfA (Assembling) and DfE (Design for the environment) (Gonçalves et al., 2009). The innermost square represents the process designs for energy optimization during the development of renewable materials (Gonçalves et al., 2009; Sutcliffe et al., 2009).

The innermost square of Design and Prototyping is further expanded and represented in Figure 3. The framework of the design and prototyping activities is inspired from the Krishnan and Ulrich (2001) model, the reliability engineering model (Cui and Khan, 2008) and the systems engineering model for Concurrent Engineering (Prasad, 1995). The upper left rectangular box illustrates the product design activities, while the lower right rectangular box illustrates the process design activities. The design activities translate user and stakeholder needs into technical specifications, that are further subjected to verification (system requirements) and validation (user/stakeholder requirements). The process design addresses the supply chain configuration in accordance with the production rate and platform requirements. The framework illustrates the critical parameters for conducting multiple iterations in order to achieve a desirable trade-off between synergies and conflicts (Ouardani et al., n.d.).

Net Present Value@Sustainability and Profitability Index@Sustainable Life Cycle Assessment

The uncertainty assessment at the initial development stages are subjective and significantly prone to error. Therefore, the NPV@Sustainability and Profitability Index@Sustainable Life Cycle Assessment (Figure 4), incorporate the ranking approach of Low, Medium and High, listed in Table 1 (More and Little, 1980). The aforementioned ranks (in Table 1) illustrate the magnitude of risk involved in commercialization of new product development, the negative impact of each process on sustainability and the effectiveness of the strategies employed for achieving sustainability. The scoring technique is explained in the following section.

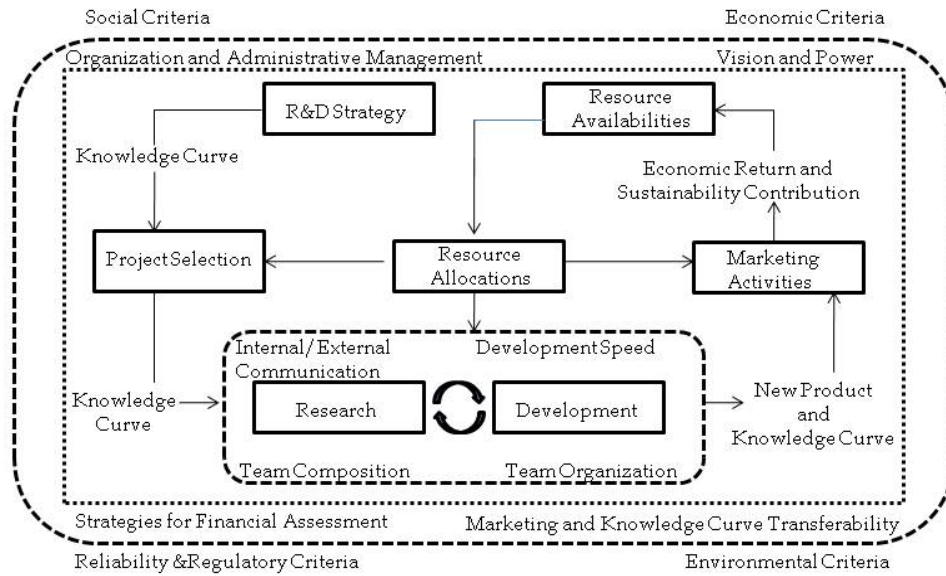


Figure 1: New Product Development Framework

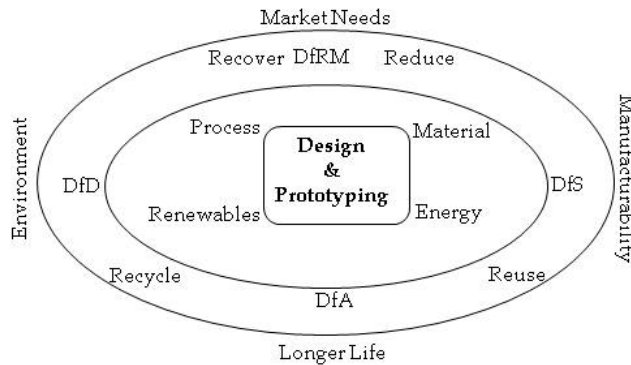


Figure 2: Research and Development

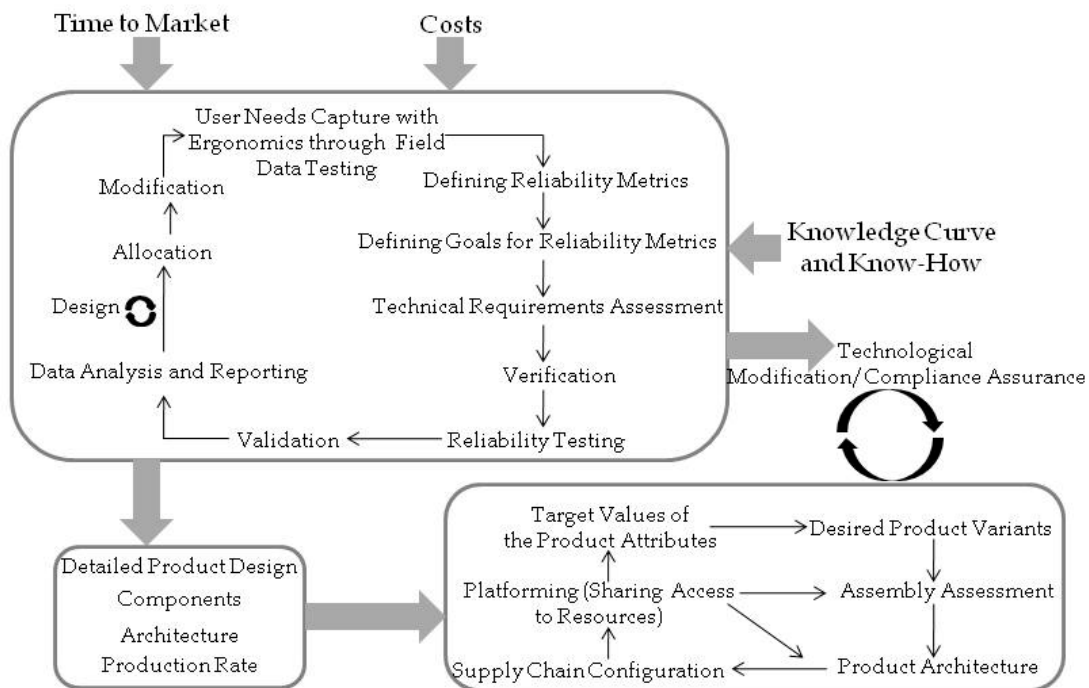


Figure 3: Design and Prototyping

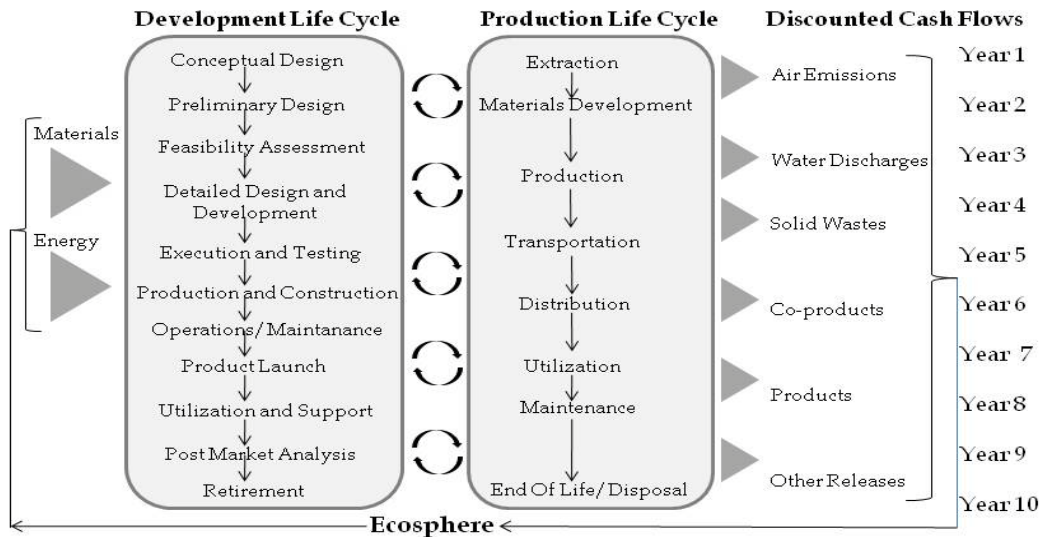


Figure 4: Profitability Index @ Sustainable Life Cycle Assessment

The NPV@Sustainability is conceptualized as a cube, wherein each side represents each facet, listed below:

- Categories of New Product Development: New

Rank	Risks	Negative impact	Effectiveness
High	0.1	0.001	0.9
Medium	0.4	0.01	0.4
Low	0.9	0.1	0.1

to the World Products, New Product Lines, Additions to existing Product Lines, Improvements and Revisions to Existing Products, Repositioning and Cost Reductions.

- Risks associated with New Product Development (listed in Table 2) (Davis, 2002; Jerrad et al., 2008).
- Environmental Sustainability (listed in Table 3) (Hauschild et al., 2005; Sutcliffe et al., 2009; Allwood, 2005).
- Social Sustainability (listed in Table 3).
- Economical Sustainability (listed in Table 3).
- Strategies to achieve Sustainability (listed in Table 4) (Sutcliffe et al., 2009; Allwood, 2005; Nasr and Thurston, 2006).

Table 1: Scoring Method

Scoring technique for Net Present Value @Sustainability and Profitability Index@Sustainable Life Cycle Assessment

In an “ideal situation”, presuming every criterion associated with the risks and un-sustainabilities, to be negligible. The assigned value would be the “ideal score of 1” for each one of them. Moreover, in such “ideal situations” the Net-Present-Value and Profitability Index, would consist of cash flows subjected only to a discount rate. However, the realistic scores (in decimal points less than 1) when multiplied with each other, would provide a clear picture on the sustainability. For example: 0.9 for using green technologies and 0.1 for inability to control high toxic emissions.

Hence for every product category, the scores (in Table 4) of each strategy towards sustainability would be multiplied with the scores of each criterion of Social, Environmental and Economic Sustainability. Thus resulting into “Sustainability Score”. Furthermore, the “Sustainability Score”, would be multiplied with each factor of every risk category to obtain a “Sustainability and Risk Score”. Finally, “Sustainability and Risk Score” would be multiplied by the Net Present Value, to obtain the NPV@Sustainability. However in the case of Profitability Index@Sustainability Life Cycle Assessment, the “Sustainability and Risk Score” for each involved process (Hauschild et al., 2005), would be calculated for every financial year and multiplied with the discounted present cash flows. Profitability Index is calculated by dividing the Present Value of all the cash flows by the initial investment.

CONCLUSIONS AND FURTHER RESEARCH

This investigation re-asserts the recommendation of Dr. Martin Charter to focus on “Innovation” in order to achieve improvised sustainability, for every developmental iteration (Charter, 1998). The proposed product development framework, illustrates potential opportunities for the inclusion of sustainable end-of-life options, that further promote sustainability (Nasr and Thurston, 2006). The Profitability Index Model, demonstrates a “much more comprehensive” approach in contrast to the Net Present Value Model.

The methodologies collectively, are supportive in nature to the involved Product Engineers and Project Managers to validate their new product ideas (Stage 2, 3) and deliver a detailed insight on the prospective challenges, they may encounter during the commercialization phase (Stage 4, 5). Despite their limited ability to recommend strategies for resolving any identified synergy/conflict, these methodologies can be applicable for devising an engineering oriented approach for achieving a desired and a “sustainable” trade-off.

Table 2: New Product Development Risks

• Financial: operational finance, access to working capital and pricing strategy.
• Personal: personal finance, family circumstances.
• Intellectual property: learning, innovation and protecting ideas/research investigations.
• Regulatory compliance: addressing policy changes, safety issues, new standards.
• Markets: competition, consumer satisfaction and market leadership.
• Technical: manufacturing processes, new technologies/materials and components.
• Partnerships/collaborations: networks to share resources and strong cross-functional teams.
• Organizational: capacity, skills, support/commitment and strong team formation/organization.
• Technological and engineering: novelty, reliability and proof of concept.
• User and stakeholder needs: detailed collection of needs and desirable trade-offs between criteria.

Table 3: Sustainability Criteria

a) Economic Sustainability
Reputation management, employee satisfaction, and financial performance.
b) Social Sustainability
Preservation of rights and cultural practices and improvised safety/welfare standards for personnel/clients.
c) Environmental Sustainability in each Life Cycle Phase
1. Quantity of utilized Energy: Fossil Fuel, Hydropower, Nuclear, Electricity.
2. Renewable and Non Renewable Resources Utilization & Toxicity, Volume and Treatment of Waste
3. Climate Change and Global Warming: Acidification, Photochemical Ozone and Ozone Layer Depletion.
4. Water Ecotoxicity: Surface/Ground Water Contamination and replenishment of safe water in ecosphere.
5. Air Ecotoxicity: Green house gasses, Eutrophication, Oxygen depletion, Noise.
6. Land Ecotoxicity: De-forestation, Desertification, Contamination of Soil compartments and Biodiversity.

Table 4: Strategies for achieving Sustainability

1) Constraints to address Sustainable Product Design and Commercialization
▪ Production Volume/Year for the desired size/structure and number of parts. ▪ Operations and Logistics in accordance with Supply Chain Compatibility. ▪ Packaging and Transportation based on Product Architecture.
2) Parameters for Sustainable Product Development
a) Resources (Energy, Material and Labour) Consumption
▪ Consider novel technologies for low resource consuming components. ▪ Minimize required material and energy resources needed and Maximize usage of expended resources. ▪ Minimize or eliminate the adverse impacts and production of waste/emissions. ▪ Substitute Toxic/Non-renewables with Non-Toxic/Renewables. ▪ Negligible contribution towards human rights abuse and political instabilities.
b) Design and Development Approaches
▪ Design for disassembly and separation, Improvised Technology and Platform Flexibility. ▪ Optimized Human-Machine interaction and Human Factors Engineering. ▪ Design for multiple life-cycles. Rapid technology turnover with higher reliability (Product reliability, durability, maintenance, restoration, life-time/use-time, safety and cleaning). ▪ Functional clusters of components with similar technical (durability) and market life (technology change rate). ▪ Evaluation parameters for the design and assessment of end-of-life options (reuse, remanufacture, recycle, or treat and dispose) for each module and component: · Value and cost of component in terms of resource consumption. · Technical feasibility of remanufacturing (component retrieval without damage). · Economic feasibility to recover components and transform into a new product. · Iterative (or synchronous) assessment process in consideration with product and manufacturing system design. · Build structures of ownership and production, to promote end-of-life options (e.g.:WEEE (The Waste Electrical and Electronic Equipment Directive)) in Europe. · Use and develop, simple and other composite materials that use scarce resources.
3) Challenges faced during Sustainable Product Development
Low weight may shorten product life and Renewable materials may cost more energy.

Future Research

The proposed methodologies can be considered for the development of a software tool through an University inter-departmental collaborative venture.

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INTER-FIRM COST MANAGEMENT IN HIGH-TECH PRODUCT DEVELOPMENT PROJECTS IN THE PLASTICS PROCESSING INDUSTRY

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KEYWORDS

New product development, Inter-organisational cost management, High-tech environments

ABSTRACT

Companies are compelled to develop new products that accomplish several objectives simultaneously. Furthermore, competition is forcing organizations to collaborate more with their business partners. To meet this wide set of objectives, companies are embracing new tools and techniques to support successful new product development (NPD) projects. Inter-organizational cost management (IOCM) has been used by organizations to achieve the collaborative management of costs throughout projects of NPD. Effective cost management which cross organizational boundaries has the potential to improve the overall performance of the project.

This paper presents and discusses inter-firm cost management in high-tech NPD projects, particularly the use of nanomaterials and nanotechnologies in the plastics processing industry. Processors are being asked to add value, complete more operations, deliver around the world, develop products and engage in partnerships with customers. In many cases, the supplier is becoming so integrated with the client that the former (supplier) is becoming linked to the success of the client. One result of this new strategic focus could be the “evolution” of IOCM.

INTRODUCTION

Advanced transformations in NPD have forced firms towards utilization of technologies that lie outside of their firm boundaries. In the automotive industry OEMs (Original Equipment Manufacturers) have formed partnerships with suppliers to take advantage of their technological expertise in development, design, and manufacturing. Accordingly, these firms continue to integrate suppliers earlier in their product development projects and to a greater extent. In fact, in recent years, firms in many industries have increasingly extended their NPD activities across organizational boundaries

and outsourced innovation (Engardino and Einhorn, 2005).

Researchers have perceived the benefits of supplier involvement in product development to be very significant (Winstra et al., 2001). It has been argued that buyers can benefit from involving suppliers early in the development process, rather than working independently when it comes to time-to-market of new products, product quality, development cost, and product cost. Supplier involvement in NPD can also help the buying firm to gain new competencies, share risks, move faster into new markets, and conserve resources. As such, to generate inter-organizational competitive advantage through supplier involvement in NPD requires the firm to build up and maintain appropriate routines and processes and to work with suppliers possessing complementary competencies in product development projects (Dyer and Singh, 1998; Johnson, 1999).

Cost is a crucial issue for enterprises' operation. Nowadays, the conventional cost management model may not be applicable on high-tech firms. Thus, industry managers and academics have been showing a particular interest in the use of sophisticated cost management (CM) practices in comparison with the long-established ones. The cost management concept - in high-tech firms - is itself innovative, scientific and technical driving model. High-tech enterprises are characterised by high technological and added value products as well as high qualified employers. Moreover, these companies are highly sensitive to scientific and technical development and external market changes. As a result, they are considered a business with high risks. On the other hand, with the purpose of realizing sustainable development, the high-tech enterprises will transfer from its single profit maximization target to multiple targets of advanced technology, customer satisfaction, high-quality products and leading position in market, as well as human resource capital increment, i.e. non-profit income.

Accordingly to Cooper and Yoshikawa (1994) and Cooper and Slagmulder (2004), nowadays the cost management process in the high-tech firms are blurring their organisational boundaries in many different ways, including sharing research and development projects,

placing their employees in other firms and developing target costing (TC) and IOCM. For Cooper and Slagmulder (2004) formal buyer-supplier initiatives undertaken to reduce costs through collaborative efforts must be included in a specific domain that they called IOCM. According to them, IOCM is characterised by three main concepts: the quality-functionality-price (QFP) paradigm, inter-organisational cost investigations (IOCI) and concurrent cost management (CCM). These three concepts or techniques have, as a common objective, the reduction of costs through changes in the initial specifications of the product or components, i.e., in the early phases of NPD process.

The purpose of this paper is to present and explain inter-firm cost management in practice and, particularly, to demonstrate how/why this approach may contribute to new paradigms in NPD management characterised by high levels of sharing, involvement and interactivity among the different players (buyers-suppliers relationships) in a supply chain. This paper presents and discusses inter-firm cost management in high-tech NPD projects, particularly the use of nanomaterials and nanotechnologies in the plastics processing industry. Furthermore, this work offers a discussion basis on the role of advanced cost management practices in NPD process and buyer-supplier relationships.

Accordingly, the article is structured as follows. Firstly, it presents a literature review on NPD and inter-firm cost management. The example of using nanomaterials and nanotechnologies in NPD projects in the plastics processing industry is presented in section two. Thirdly, the case in point (inter-firm cost management in NPD high-tech environments) is explained and discussed. Finally, conclusions and some implications and opportunities for future work are presented.

LITERATURE REVIEW

New Product Development Projects

The success of NPD depends on several factors, such as: introduction of new raw-materials, growth complexity's product and customer needs. On the other hand, it is extremely important to achieve a desired efficiency taking into account the developing and launch times of products, by controlling costs and developing high performance products (Osteras et al., 2006). Hubka and Eder (1988) defined the product performance variables in three different categories: *design properties* (e.g. function, surface, raw-materials and dimensions), *internal properties* (e.g. resistance, tenacity, hardness, elasticity and corrosion) and *external properties* (e.g. ergonomic, aesthetic, maintainability and safety). To the final customer it is particularly interesting the later properties.

In the literature, the NPD process is normally divided from six to nine steps. Calantone and Benedetto (1988) and Griffin (1997) address, at the earlier NPD stages, alignment activities of the new products with the

company's strategy. Ulrich and Eppinger (2000) and Cooper (2001) also mentioned that these tasks are important for the development process, at the earlier stages, but they did not include them specifically into the NPD flow. In the model developed by Osteras et al. (2006) the NPD process is divided in six phases: *i)* front-end, *ii)* design, *iii)* design details, *iv)* components development, *v)* product prototype development, and *vi)* production and two stages: *i)* pre-development, and *ii)* development and production. Tzokas et al. (2004) suggested that the NPD process is followed by six evaluation phases, named by gates or convergent/decision points. The end of a phase and the beginning of another is marked with a *gate*, where all performed activities and obtained results are verified. Approval in such gate means that the process is ready to jump to the next phase. The evaluation gates allow: *cleaning ideas, testing concepts, analysing on the business perspective, performing functional tests on the product, analysing the research market results* and, finally, *evaluating the product launch to the market*.

In the plastics processing industry, product development is an interdisciplinary activity that requires contributions from nearly all the functions of a firm. However, three functions are almost always central to a product development project: marketing, design and manufacturing (Barbosa, 2008). The marketing function mediates the interactions between the firm and its customers and also facilitates the identification of product opportunities, the definition of market segments and the identification of customer needs. Marketing also typically arranges for communication between the firm and its customers, sets the target prices and oversees the launch and promotion of the product. Furthermore, the design function plays the lead role in defining the physical form of the product to best meet customer needs; it includes engineering design (mechanical, electrical, software, etc.) and industrial design (aesthetics, ergonomics, user interfaces). For example, when all aspects are closely interwoven, polymeric materials are able to solve design problems most elegantly and with certain economic advantages. Finally, manufacturing is primarily responsible for designing and operating the production system in order to produce the product. The manufacturing function often includes purchasing, distribution and installation activities. A successful design is usually a compromise between the requirements of product function, productive and cost. Basically design is the mechanism whereby a requirement is converted to a meaningful plan (Rosato et al, 2000).

In this industry, a multidisciplinary team develops the majority of the products and very few of them can be developed less than 1 year. This team usually has a team leader who could be drawn from any of the functions of the firm. The team can be thought of as consisting of a core team (mechanical designer, purchasing specialist, marketing professional, manufacturing engineer, etc.)

and an extended team (other people connected with core team, including suppliers) (Ulrich and Eppinger, 2003).

Inter-firm Cost Management in NPD Projects

The literature regarding target costing suggests that this internal cost management technique is not actively involved in the cost management program of partner firms (Monden 1995; Cooper and Slagmulder 1997, 2004). TC aims to identify the cost at which a product should be manufactured. When the target cost is broken down to component level, the supplier is usually involved. The key extension of TC that brings it into the realm of IOCM is the active involvement by both the focal firm's and the partner firm's design teams in the joint identification, management, and resolution of cost issues (Cooper and Slagmulder, 2004). This makes TC one of the most important parts of IOCM practices that involve both buyers and suppliers in NPD projects. One of its most prominent characteristics is that it tends to push cost pressure further upstream in the supply chain. The importance of the supply chain is therefore often stressed in the TC literature. Ansari and Bell (1997) argue that "An optimized supply chain is one of the most critical elements in attaining the target cost". Sakurai (1996) stated that "the primary objects of target costing are direct material costs and direct conversion costs". It is, therefore, not surprising that most stage models of TC should deal conveniently with the supplier or the purchasing function (Ellram, 2000).

IOCM refers to a set of activities, processes or techniques that managers can use to manage costs that span organizational boundaries (Cooper and Slagmulder 2004). According to Cooper and Slagmulder (1998a), IOCM practices facilitate the coordination of cost reduction in two ways: *i)* helps identify ways to make the interface between the firms more efficient, and *ii)* helps the firm and its buyers and suppliers find additional ways to reduce the costs of products.

Cooper and Slagmulder (2004) identify three specific IOCM approaches resulting from target costing processes that progressively involve more collaboration between the focal firm and the partner firm: *i)* the functionality-price-quality paradigm, *ii)* inter-organizational cost investigations, and *iii)* concurrent cost management practices. FPQ tradeoffs are associated with small design changes that can be accommodated by a single firm in the supply chain with the permission of at least one other firm. It is useful for resolving minor cost overrun problems and requiring limited interaction between the design teams of the focal and partner firms. IOCI are associated with more significant changes that require modifications to the design or production processes of the items produced by more than one firm in the chain. These design changes are interrelated, but they can be accomplished with relatively low levels of communication between the design teams. Finally, CCM is associated with the most significant changes. It

requires significant interaction and collaboration between design teams and can lead to fundamental changes in both firms' product and processes. It aggressively reduces costs by increasing the scope of design changes that the supplier can undertake involving suppliers early in the NPD project. Cooper and Slagmulder (2004) provide a complete discussion of these three techniques via case analysis, demonstrating how these IOCM techniques have been used in three Japanese supply chains to cooperatively identify mutually beneficial low-cost solutions.

Karjalainen and Ojapalo (2006) verified, for the first phase of NPD process, that the definition of target cost is an important issue on the NPD but does not present itself as a fundamental principle – otherwise it could harm the technology as well as the product functionalities and, consequently, challenge the customer satisfaction. In the model developed by them seven steps for the cost management in such cases are presented: *i)* identification of customer needs, *ii)* market research in order to analyse the most competitive products, *iii)* concept generation, *iv)* exclusion of other generated concepts in order to get/select only one concept, *v)* goals definition as well as TC by means of economic analysis, *vi)* project planning and development, and *vii)* description, in detail, of the product specifications with the purpose of verifying the product position in the market. The later step is supported by concept generation teams which are interacting with customers.

On the other hand, Davila and Wouters (2004) found out that in this kind of companies, TC management presents four strong limitations: *i)* it concerns only with product costs discarding the product's ability to generate profits, *ii)* is a long term implementation technique, *iii)* extremely bureaucratic, and *iv)* is a linear technique implementation and particularly detailed. These authors identified and analysed techniques which require a lower focus and degree of complexity than those based on TC in order to allow a more effective costs reduction on the model costs development. For instance, the formation of parallel multidisciplinary teams for cost management, the definition of cost management strategies, the use of components and common processes, the modular conception and the development of product planning platforms. A weak point of non-TC approaches is related to the fact the multidisciplinary team is particularly focused on technology undervaluing cost management.

NANO- MATERIALS/TECHNOLOGIES – IN THE PLASTICS INDUSTRY

The Plastics Production Chain

In 1951, two young research chemists of Phillips Petroleum Company in Bartlesville, Okla., made discoveries that revolutionized the plastics world. Today, the plastics they discovered – polypropylene and

polyethylene – are used to produce the vast majority of the thousands of plastics products all over the world.

The technological road from oil field to finished plastic products presents numerous side trips, as it can be seen in Figure 1. First of all, petroleum is extracted and transported to a refinery company, known as 1st generation petrochemicals; here, oil is refined into numerous petrochemical products. From a colourless liquid fraction of oil, named naphtha, raw-materials such as ethane, propane, etc., are obtained and "cracked" into monomers (ethylene and propylene, respectively) using high-temperature furnaces.

Afterwards, in the 2nd generation petrochemical companies, catalysts are combined with specific monomer in a reactor, resulting in "fluff," a powdered material (polymer) resembling laundry detergent that is combined with additives in a continuous blender. The melted plastic resin (combination of polymer and additives) is then cooled and fed to a pelletizer that cuts the product into small pellets that are shipped to customers. The latter, represent the 3rd generation companies, manufacture plastic products for the final customer by using processes such as extrusion, injection moulding, and blow moulding.

At this point, it is important to distinguish between polymer and plastic. Thus, in the practical case, the macromolecular substance, or polymer, will contain adventitious impurity or impurities arising from its production process as well as intentional additives to achieve specific effects either during fabrication or in the end product (Ogorkiewicz, 1974).

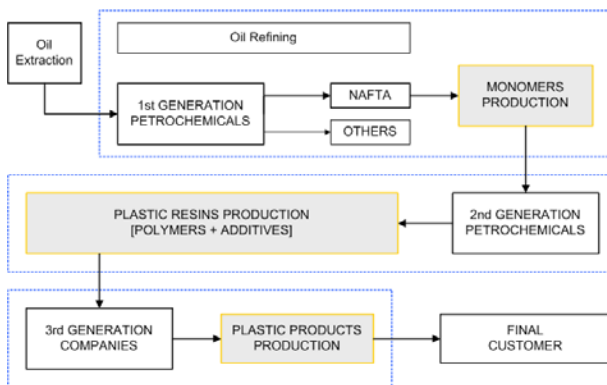


Figure 1: Technological road from oil to plastic products

It is precisely the inclusion of these additives, and even reinforcements (such as fibres, the much spoken nanoparticles, etc.), that can change some properties (for instance: mechanical and electrical properties, corrosion susceptibility and degradation, wear resistance and frictional properties) of original polymers.

Injection moulding, right after extrusion process, is the most widely used process to form plastics. Its principle is quite simple: a thermoplastic, in the form of granules or powder, passes from a feed hopper into the barrel where it is heated so that it becomes soft; it is then forced through a nozzle into a relatively cold mould

which is clamped tightly closed; when the plastic has had sufficient time to become solid the mould opens, the article is ejected and the cycle is repeated. This processing technique is used for a wide variety of plastic products, from small cups and toys to large objects weighing 30 pounds or more. The major advantages of the process include its versatility in moulding a wide range of products, the ease with which automation can be introduced, the possibility of high production rates and the manufacture of articles with close tolerances. Injection moulding is considered the most important of all the commercial methods of plastics processing. Many variations have been developed and one of the rapidly expanding fields is multi-material injection moulding. This is particularly important where processors are looking to gain technological advantages over rivals and even clients by adding value to products. Whilst tooling costs can be very high, cost savings can be obtained by eliminating assembly steps (Barbosa, 2008).

Nanomaterials and Nanotechnologies

Nanotechnology is a technological revolution that will radically impact almost every sphere of modern society, particularly manufacturing processes and the way businesses operate. It will enable the manufacture of products with incredible precision that will be stronger, lighter, and "smarter" than anything that exists today.

During the initial phases of the life of a product – R&D, prototyping, and initial production – there is no revenue generated from the product. Since the initial development costs are higher in nanomanufacturing, the losses in the initial period are higher as well. However, the situation changes once sales commence. The use of nanotechnology will result in much lower production costs and consequently higher gross margins. Thus, the increase in profits in a nanoenvironment due to an increase in sales will be greater than those in a traditional manufacturing environment (Dutta et al., 2006).

As nanotechnology evolves from the laboratory into an industry, one of the greatest challenges still to be overcome is the penetration of nanotech products into mainstream user markets. It takes time and effort for nanotech companies to find potential customers, convince them to evaluate a new product, and ultimately have them purchase the product in commercial amounts. There are many things within management control that can reduce the time for transforming sophisticated nanotech research into revenue-generating products. These include decisions related to what and how has been developed, how the resources have been applied, and how convince potential customers to buy sooner rather than later (Gordon, 2002).

In the plastics processing industry, nanocomposites are a novel class of polymeric materials exhibiting superior mechanical, thermal, and processing properties, suitable to replace metals in automotive and other applications.

The use of nanocomposites in vehicle parts and systems is expected to improve manufacturing speed, enhance environmental and thermal stability, promote recycling and reduce weight, enabling the automotive industry to capture a leadership position in fuel-efficient, higher-quality, and durable vehicles (Garcés et al., 2000).

Nanocomposites may be produced by the incorporation of nanometre-size particles in polymers such as polypropylene (PP), polyethylene (PE), polyesters, epoxies, etc. Several routes are currently proposed to make polymer nanocomposites. The nanomaterials can be dispersed into polymers by conventional melt compounding or solution methods. Alternatively, nanocomposites can be made by the in-situ polymerization method. This method was pioneered by Toyota Motor Company to create Nylon 6-nanoclay hybrid (NCH), used to make a timing-belt cover, the first practical example of polymeric nanocomposites for automotive applications (Garcés et al., 2000).

A wide variety of types, morphologies and dimension of nanomaterials are becoming available from a number of commercial sources. Nowadays, the polymer composite community is presented with the challenging task of producing composites bearing the multifunctionality of these nanomaterials. Each nanoapplication requires customized nanomaterial that may need additional developments. Recent results on production of polyolefin nanocomposites by melt processing of organo-clays with modified polymers or by various in-situ polymerization methods suggest that these materials can be produced with current technologies (Garcés et al., 2000). The current challenge is to develop nanocomposites at competitive cost and with superior performance – which requires a great investment in R&D – to replace metals and/or existing polymeric filled composites.

The Use of Nanoparticles in Colouring Technology to Avoid Additional Painting and Reducing VOCs

Automotive manufacturers are on quest to reduce weight and fuel consumption, increase the recyclability of automotive parts and body panels while maintaining their capability to compete based upon cost, appearance, and performance. In order to meet those goals, an automotive manufacturer have undertaken a NPD project aiming to produce a part of a car, in a more automated, cost-efficient and integrated process. It is an assembled component, composed of two different parts, currently produced by two different companies; each developed separately but finally assembled together. This case reveals the possibilities open to SMEs operating in intensive supply chain environments in the car manufacturing industry. Thus, this case shows how the integrated effort of the different companies work in the development of the integrated component can significantly increase the pace of product manufacture from the initial concept to the final part. It demonstrates

also the importance of including 2nd generation petrochemicals (raw-material developers/suppliers) in the product development stage.

The initial approach is to make use of nanoparticles in colouring technology to avoid additional painting and reducing VOCs (volatile organic compounds). This new technology will allow manufacturers to increase production rates and consolidate scattered production sites to reduce manufacturing costs by, for instance, lowering equipment and labour requirements. Firstly, the customer contacts the design/engineering consultant company about a specific need for a plastic component. The customer has an initial concept of the component and the specifications that constrain its development. The specifications must reflect customer needs, differentiate the product from the competitive products and be technically and economically realizable (Ulrich and Eppinger, 2003).

In these cases, one of the main factors influencing the product development is the correct material selection. Factors that need to be studied include strength, stiffness, ductility, hardness, fatigue resistance, impact strength, processability, and costs (both raw material and manufacturing) - Crawford (1985). This stage is usually completed by analysing available material databases (which may be supported by appropriate computer software). However, when a new material (with nanoparticles for colouring technology) is required, it is vital that the raw-material supplier is involved in this stage as there is very little or none information at all in the above mentioned material databases. Furthermore, each nano-application requires customized nanomaterial that for sure needs additional research and development efforts.

Additionally, in selecting a polymeric material, it is vitally important to decide at the same time on the method of manufacture of the component, and to take account of the effects of processing on properties (McCrum et al., 1988). In possession of such information regarding material properties and characteristics, and processing technique, design engineers are able to move forward in conception/project phase. The philosophy behind this stage is to create a high-quality information channel that runs directly between customers in the target market and the product developers. Here, there is a premise that those who directly control the details of the product, including the engineers and industrial designers, must interact with customers and experience the environmental use of the product.

Reducing cost at the design phase is very important in terms of cost management and it has a rapid reimburse for the effort involved. Defined the length, width, height, wall thickness and material type, at least 80 % of the product cost is defined. With any design project the first 15 to 20 % of the project involves very little actual cost but it defines and commits between 80 to 90 % of the final product cost (Kent, 2002).

Flow and structural analysis (such as finite element analysis, using commercially available software packages) are generally carried out in order to minimize all the repetitive/iterative and time and cost consuming tasks necessary for part's optimization. At this stage, designers predict the physical behaviour of a part under loading conditions. This analysis enables faster, cheaper, and optimized product development, as well as more in-depth examination of product performance than it would ever be possible using the most detailed prototypes (Barbosa, 2008).

When prototypes are suitable for the preliminary testing and evaluation of a product they will provide a way to evaluate the product's performance before going into production. They are used to validate the concept, which in turn may be realized that require additional refinements. It must be kept in mind that prototype testing to verify performance is usually the most important step in the overall design process of any product because, a visual, tactile, three-dimensional representation of a product is much easier to appreciate than a verbal description (Barbosa, 2008). Furthermore, these prototypes are usually requested to ensure that components of the product work together as expected. At this moment, the product development stage ends.

Injection moulding company is then contacted to produce the final integrated component. However, the manufacturing tool (mould) is necessary, and the product manufacturer usually outsources its development. The mould design presents itself as a challenge. The mould designer must take numerous factors into account, such as the intrinsic characteristics of the material, in order to prevent further issues. To provide the best design, the product designer, processor, and mould designer may want to jointly review where compromises can be made to simplify meeting product requirements. For the tool development, flow analyses are also required. These analyses are also useful for optimizing processing conditions in the production stage.

It becomes clear that a correct integration of all participants in the production of a product, from its initial concept to its production, reduces the risks for the occurrence of errors, enables refinements of the product, tool or process without compromising delivery times, costs or performance. Specially, when these "complex" products consists of multiple components that require multiple domains of technical expertise to produce and integrate, produced by several organizations and integrated by a systems integrator who defines their overall technical architecture. The example presented in this section shows how the use of nanomaterials and nanotechnologies will ask for a higher involvement of materials suppliers (who in general are not involved in the NPD process) and will extend cost management to R&D activities.

The inherent technological complexity of designing and producing these products should result, since the

beginning of the new component development process, in networks of sub-system producers and specialized suppliers collaborating around the required product. Figure 2 presents these network processes with its participants and relationships.

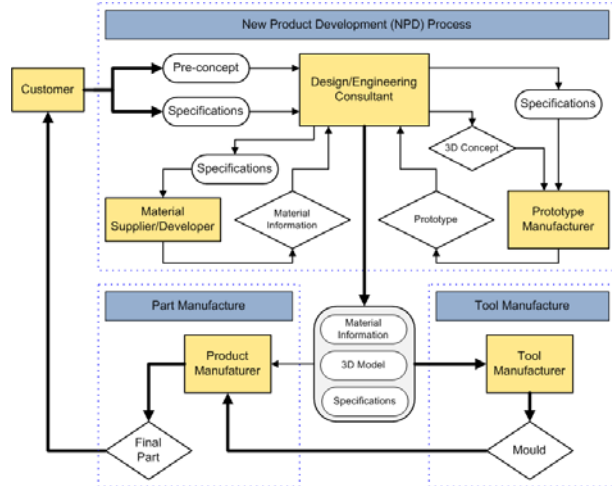


Figure 2: Network of NPD in injection moulding industry

High-tech environments as they are those based on nanomaterials and nanotechnologies demand for complex and interrelated NPD processes where suppliers have a much more active role than in traditional NPD projects. Supplier involvement in NPD projects has been increasing these last years from superficial and episodic collaborations to deep and early contribution to the design of new products. High-tech products, materials and technologies represent a new step in suppliers' involvement in NPD projects.

INTER-FIRM COST MANAGEMENT IN HIGH-TECH NPD PROJECTS

Suppliers' participation in cost cutting plans and efforts has been moving from the production stage (with kaizen costing for example) to the design stage (IOCM practices) and more recently to the conception stage. This happens because suppliers have now more and important competencies (particularly in manufacturing operations and technology) than in the past. Nevertheless, the use of high-tech materials and technologies reinforces suppliers' relevance into the NPD processes and definitely includes them into the value chain R&D activities. Consequently, inter-firm cost management practices in NPD projects are now more demanding and involve buyers and suppliers in an extended and deeper way. The literature on IOCM should be extended with this different type of inter-firm cost management in high-tech NPD environments. The plastics processing industry is a very interesting case study.

In fact, cost management is a vital topic in plastics processing. Processors are being asked to engage in

partnerships. Suppliers and buyers are becoming so integrated that the former is becoming definitively linked to the success of the buyer. The increasing customer pressure for “cost down” or “target cost” production is creating a new climate for processors that now need to have exceptional control over the real costs on processing. Increasing competition has seen plastics processing become a truly global business and companies that are not able to compete in a global market will soon find even their local markets disappearing. Processors need to compete not only with the best in their local area but with the best in the world. A good cost management will improve profits and margins. It will improve management control and it will open the door to becoming a world-class company. Indeed, cost management is still seen as vital to the success of any manufacturing company in any sector (Kent, 2002).

In the plastics processing industry, the design and development process locks cost into the product at a very early stage. The new product design starts to become fixed at a very early stage and the basic costs become fixed early in the project. The control of the number of parts, the materials content and the basic processing methods are all fundamental to cost management and the decisions that govern these are all made during the design and development phase. Product designers/engineers and their assumptions influence product cost from the very start of any project (Kent, 2002).

An effective IOCM, according to Cooper and Slagmulder (1999a), requires the integration of both disciplining and enabling mechanisms to reduce costs across the supply chain. Disciplining mechanisms aim to transmit the cost-reduction pressure throughout the network by setting objectives for every aspect of buyer-supplier interactions. The objective of the enabling mechanisms is to help the firms in the network or chain to find ways to pool their skills and co-ordinate their efforts so they can collectively achieve the cost-reduction objectives. The potential for cost reduction via product design is enormous.

In this context, information sharing and inter-firm collaboration are central to the success of NPD projects. A symbiotic relationship develops whereby co-operating organisations share cost and performance information resulting in analysis and adjustment of interdependent activities and some sharing of costs and benefits (Dekker, 2003). Different forms of relational context exist, ranging from relationships that closely resemble markets to strategic partnerships in which organisations signal their desire to work very closely over the long-term (Cooper and Slagmulder, 2004).

IOCM is concerned with the cooperative efforts of members of separate organisational units to modify cost structures and create value for its participants. When trying to reach the target costs at the component level, the buyer can approach its suppliers in various ways and

the degree of cooperation varies. Ellram (2000, 2006) points out that if the purchased component has significant economic impact, more efforts will be spent on supplier selection and changes in design and materials. Less important components lead to more distant approaches, e.g., competitive bidding. Activities related to product development are often critical and during this process, cooperation between buyers and sellers can become very close. To reach the target cost, it may be applied techniques such as quality–function–price tradeoffs, interorganizational cost investigations and concurrent engineering.

Target costing (TC) means determining the expected selling price, derived from the market (as opposed to the costs), before the product is developed, and then calculating the target cost subtracting the expected profit to the price. Therefore, the TC process covers the entire life cycle of a product, although the focus in the literature is on preproduction stages. The literature on IOCM has made valuable contributions to our understanding of these buyer-supplier hybrid relationships. Nevertheless, there remains plenty of scope for further development.

Nanotechnologies and nanomaterials will have a huge impact in NPD processes and consequently in cost management practices in NPD projects; particularly, in inter-firm cost management practices with the increased relevance of suppliers from R&D to production stages of a new product.

Nanotechnologies and nanomaterials will significantly reduce production variable costs but they will require significant up-front technological investment. The advent of nanotechnology is likely to affect the extended value chain in every major industry. For some organizations, nanotechnology will have a direct effect on their internal value chain. For others, it will have an indirect effect through the external value chain (which extends forward and back to include suppliers' and customers' value chains) of which they are a part. The impact of nanotechnology, from a profitability and cash flow perspective, will likely be far greater for those organizations that adopt this technology, thereby affecting their internal value chain, than for those that are a part of an extended value chain adopting this technology. The impact will primarily be restricted to the shifting of costs from downstream (such as failure costs) to upstream (higher cost for parts manufactured through nanotechnology). This shift in costs, however, may be accompanied by a shift in the profitability of the various segments of the external value chain, and companies should perform a value-chain analysis prior to negotiating with suppliers or making strategic investment decisions in this new environment (Dutta et al., 2006).

Under conventional technology, typically 80 to 90 per cent of the total costs associated with a product are committed in the early stages of a product's life cycle. By the time production begins, while much of the costs

remain to be incurred, there is little ability to control the magnitude of these costs, as they have already been “designed in”. With nanotechnology, both the percentages of costs committed and costs incurred early in the life cycle of a product will be even higher. Early consideration of the total cost incurred over the entire life cycle of a product, rather than just the cost of manufacturing, becomes much more important. Thus, cost management in NPD projects will be particularly relevant in these environments. Furthermore, the role of suppliers in the cost reduction effort will be higher and it will appear sooner asking for effective inter-firm cost management practices. Indeed, organizations adopting nanotechnology in their manufacturing will face much higher initial developmental costs than previously incurred. However, nanomanufacturing techniques will reduce the costs of production and other downstream costs. In traditional manufacturing incurred costs are more evenly spread over a product's life cycle, with significant costs incurred in the production, sales, and after-sales phases. Companies utilizing nanomanufacturing techniques will incur most costs upstream in the development and prototyping phases and relatively few costs in the production, sales, and after sales phases (Dutta et al., 2006). This fact contributes also for the relevance of inter-firm cost management in these NPD environments.

Furthermore, much of the capital investment of a nanoproject will be required early in the product life cycle. Additionally, there is a higher degree of uncertainty regarding the initial cash outlay, due to the newness of nanotechnology. For nanotechnology, although the break-even point is achieved later in a product's life cycle, profit grows at a faster rate than with traditional manufacturing and could eventually exceed the profit levels attained under traditional manufacturing. Similarly, although the payback period is likely to be longer for nanotechnology, future cash flows could also be larger in the later stages. The gross margin in the nanomanufacturing environment is higher – this outcomes in a greater sensitivity of profit to changes in sales volume. The profit margin in the traditional manufacturing environment is lower due to relatively higher production costs; hence, there is less sensitivity to errors in forecast. This is represented by a narrower probability distribution for traditional manufacturing techniques, denoting a lower variance in profits (Dutta et al., 2006).

CONCLUSIONS AND FURTHER RESEARCH

In this research project, inter-firm cost management in high-tech product development projects in the plastics processing industry and related techniques were analysed. The objective was to contribute to the understanding of inter-firm cost management in high-tech product development projects and related techniques in practice. Traditionally, cost management

has been concerned with cost reduction initiatives (i.e. cutting costs plans), the development of costing and cost information systems and the establishment of effective cost control procedures. Nowadays, firms are developing methodologies for reducing the cost of the product before it's manufacturing. Effective management of costs, which cross-organizational boundaries, has the potential to improve the overall performance of each firm in the value chain. In particular, high-tech enterprises must know about its characteristics by analysing the value chain and constructing its own featured value chain that may consist of supply, production, storage, marketing, service, purchasing, technology development and human resource management as well as auxiliary works and management functions. It must be sure what kinds of activities are useful for reducing cost and carrying out competitive strategy to eliminate no added value works and realizes overall cost management.

In this context, supplier involvement in NPD implies the combination of the buyer's and supplier's R&D resources and the exploitation of joint capabilities through strategic integration of the buyer-supplier relationship. The firm's new product related competitive position hinges on the supplier's resources and capabilities as well as the inter-firm relationship maintained. The need for achieves target performances, quality characteristics, and target prices for all systems and subsystems are major drivers for the involvement of suppliers. Furthermore, being earlier part of the product development process, suppliers are expected to accept more responsibility for development, design, integration, manufacture, qualification, delivery, target performances, and quality for their particular systems and subsystems on the basis of frame specifications and target prices.

This paper shows how inter-firm cost management contributes to NPD management and buyer-supplier relationships in product development projects in the plastics processing industry. Particularly, how and why inter-firm cost management may contribute for new paradigms in NPD management characterised by high levels of sharing, involvement and interactivity among the different players in a supply chain (i.e. buyers and suppliers) as it is the case of using nanomaterials and nanotechnologies in the plastics processing industry. Organizations adopting nanotechnology in their manufacturing will face much higher initial developmental costs than previously incurred. One result of this new strategic focus could be the “evolution” of IOCM (Coad and Cullen, 2006). Cost management was extended to suppliers through Kaizen costing activities which means cost reductions in the production stage. Nevertheless cost reduction targets at this stage are limited and suppliers have been progressively included into the NPD process in deeper and earlier ways. IOCM represents this new approach. Suppliers became important partners in the conception

and design phases of a new product. However, R&D activities and the involvement of materials suppliers are not characteristics of IOCM environments. The use of nanomaterials and nanotechnologies is pushing an evolution of IOCM where suppliers and inter-firm cost management are more complex, appear earlier and are vital for the success of the entire NPD process. The adoption of this extended IOCM approach will contribute to blur cost management and further research should be made in order to validate and extend these conclusions. Particularly, it is expected further research through case studies in the plastics processing industry.

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COST ANALYSIS FOR ECONOMIC EVALUATION OF HEALTH CARE SERVICES

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Health Care Services, Economic evaluation, Cost analysis

ABSTRACT

Health care costs have increased significantly over the past years, especially due to the accelerating development of new diagnosis and therapeutic technologies and therefore the increasingly life expectancy, which have reported the need to maximize the results through the application of allowable resources. In this context, the development of models for economic evaluation of health care services stands for the analysis of comparative alternatives, evaluated in both their costs and their benefits.

In this article we examine the different models of economic evaluation of health care programs/services (cost-minimization, cost-effectiveness, cost-utility and cost-benefit), considering also the analysis of the various types of costs incurred and the ways to measure them, regardless the fact that indirect costs represent, in health care organizations, a considerable amount in the total cost of health services.

We thereby present a study on the possible ways to apply the various models of economic evaluation, the advantages and disadvantages of those applications in a Portuguese hospital.

INTRODUCTION

Limited resources have alternative uses. When choosing the way to apply the allowable resources, we are forgoing the opportunity to use them in one way and sacrifice the other.

The use of economic evaluation models account for the use of a powerful instrument of management in the decision making, helping both the politicians and health care professionals, by giving a more precise information on the consequences of a certain use of resources. Therefore, if not made, it brings on a much higher level of uncertain and risk, taking a chance on the making decisions which may break the socially accepted values. Cost evaluations can thereby help to establish the priorities for what should be funded and what may not be affordable (Halpin, 2006). The concept is used in its

more restricted way when there is a comparison between two or more alternatives and when there is a simultaneous evaluation of the consequences and costs of those alternatives. Only four approaches fulfil these demands: cost-minimization analysis, cost-effectiveness analysis, cost-utility analysis and cost-benefit analysis.

However, it is crucial that all costs considered under analysis are well identified and measured. There are four aspects to consider when identifying the resources involved in a cost evaluation: the viewpoint of the analysis, the extent to which the comparison is restricted to the health care programmes immediately under study, the extent to which some costs are merely likely to confirm results that would be obtained by consideration of a narrower range of costs and the relative order of magnitude of costs.

The main categories of costs in health care programmes, treatments and services are organizing and operating costs within the health sector namely, costs borne by patients and their families and costs borne externally to the health sector, patients and their families (Drummond et al., 1987). Furthermore, they should be added the costs borne by the rest of the society. Health service costs include labour costs, capital costs and overhead costs. In an economic evaluation, these costs are considered to be direct costs. Costs borne by patients and their families include out-pocket expenses such as travel and any costs resulting from care activities provided by the family or other informal carers. These costs are also taken as direct costs. Yet, the costs that may occur for both patients and their families that are related to the lose time from work whilst seeking and obtaining health care are measured as indirect costs. In addition to direct and indirect costs, a third category is likely to be taken under study: intangible costs. Intangible costs constitute the pain, anxiety and general unpleasantness associated with the provision and receipt of health care.

The major or minor assessment of each category of costs is likely to be related to the adoption of an approach for cost evaluation in an economic or financial point of view, there is, in a perspective related to merely appreciation of costs and financial advantages or in a perspective that also takes under consideration the impact that health care programmes may reveal in the well being of the patient, his family or even the welfare

of the society. However the perspective under analysis may be it is rather important that any economic evaluation carries out the benefits to exceed the associated costs.

New diagnosis and therapeutic technologies and therefore the increasingly life expectancy ask for the development of better models for economic evaluation of health care services which should evaluate both costs and benefits of the different alternatives.

In this paper we examine the different models of economic evaluation of health care programs/services (cost-minimization, cost-effectiveness, cost-utility and cost-benefit) considering the various types of costs and the ways to measure them. We thereby present a study on the possible ways to apply the various models of economic evaluation, the advantages and disadvantages. For this purpose it is presented and discussed a case study on a Portuguese hospital. Thus, this paper is structured as follows. Next sections give an overview of economic evaluation and cost concepts in health care services. Cost analysis methods (cost-minimization analysis, cost-effectiveness analysis, cost-benefit analysis, and cost-utility analysis) are presented in more detail in section three. These sections are followed by the case study section and by a discussion section. The discussion is centred on the use of GDH in Portuguese Hospitals. Finally, the last section presents some conclusions and opportunities for further research.

ECONOMIC EVALUATION OF HEALTH CARE SERVICES

Economic evaluation deals with costs and benefits and only when this information is available can decisions be made regarding the combination of health care interventions which should be made available to maximize benefits from the available budget. The basics of economic evaluation involve identifying, measuring, valuing, and comparing the costs and benefits of alternatives being considered (Drummond et al., 1987). The benefits of an intervention are usually health improvements, which can be measured in a number of ways including Health effects, Economic benefits and Value of the health improvement (see Table 1).

Health effects are for example, cases found, cases prevented and lives saved. Economic benefits that can be measured in direct (savings in health care costs because the program makes the person healthier), indirect (individuals are able to return to work), and intangible benefits (monetary value of the reduction in pain and suffering). Finally, the value of the health improvement represents the value to the patient, family and society, regardless of the economic consequences.

Table 1: Benefits of an Intervention

Health effects	cases found, cases prevented and lives saved	
	direct	savings in health care costs because the program makes the person healthier
Economic benefits	indirect	individuals are able to return to work
	intangible benefits	monetary value of the reduction in pain and suffering
Value of the health improvement	the value to the patient, family and society	

The economic evaluation comprises a number of techniques for assessing the efficiency or value for money provided by health care programs. There are several methods which depend to the measurement and valuation of health outcomes. There are a few guidelines for assessing the validity of an economic evaluation. Namely, the question is presented in a correct manner and it is possible to answer it? There is a correct description of all alternatives? For each alternative, all significant costs are considered? Are costs and consequences correctly measured? A sensitivity analysis will be performed?

In these economic evaluations not all costs and benefits occur at the same time, for example, costs of prevention are incurred early to produce benefits later. Costs and benefits occurring at different times should be weighted differently. For this we should use investment appraisal techniques, i.e. cash-flow analysis and the computation of net present values and internal rates of return.

Furthermore, in an economic evaluation of health care programs there is a trade-off between alternatives more costly but more effective and between alternatives less costly but less effective. If there is an alternative less costly and more effective, this alternative dominates the others. Besides, if an alternative is simultaneously more costly and less effective it will be rejected. Thus, all alternatives under comparison can be represented into a two-dimension graph of costs versus effectiveness.

COST CONCEPTS IN HEALTH CARE SERVICES

When resources are used to provide health care for one patient, they are unavailable for other patients and other societal uses. Thus, one cannot judge the merits of a medical intervention without understanding what one is giving up to provide that intervention.

What providers and society are willing to give up to provide treatment for one individual is called the cost of the treatment. Cost evaluation demands that a precise analysis and measure of costs be developed so that the decision to which resources are allocated can also be as

accurate as possible. As a result, it is very important that all costs are correctly identified. Nevertheless, it should be underline that it is only relevant to identify the major costs, i.e., it may not be worth investing a substantial amount of time and effort considering costs that are small and therefore likely to make any difference to the results of the economic evaluation.

In the context of health services, the direct costs refer generally to the monetary value of goods, products, services and other resources consumed in providing health care services, as well as other costs which result from side effects of the medical intervention. Therefore, hospital costs, spending on supplementary diagnostic and nursing care, the expenses incurred by the patient's death, among others, are considered direct costs. Should also be included all no medical expenses related to treatment, related to the provision of informal services such as nursing care by family members at home and other services intended to prevent or eliminate the risk of recurrence or occurrence of other diseases. They should also be considered direct costs all costs of the treatment related with the patient and his or her family, such as the transportation costs, accommodation expenses or maintenance costs of equipments in their own homes. For the direct costs should also be included expenses associated with research, personnel training, investment in buildings and other facilities which support actions of prevention and treatment of the disease.

Regarding indirect costs, this category should account for the costs incurred because the patients due to the treatment, seeing their life expectancy increased, consuming more health care services in the future. However, these expenses should only be considered if they arise directly from the therapy or treatment in question. Indirect costs, so will mostly be used to reflect the economic consequences of losses or gains in productivity (reduction in productivity resulting from changes in individuals' health status - morbidity and mortality, lost productivity at work and/or time wasted by relatives).

The psychosocial costs (e.g. social isolation or behavioral changes associated with social dysfunctions), anxiety, family conflict or, for example, pain and discomfort felt by the patient through the use of invasive surgical techniques, should be included in a third category of costs: the intangible costs, which, by measurement difficulties are rarely quantified and valued.

It is usual to consider three categories of relevant costs for an economic evaluation in health care services which are explained in Table 2.

1. Health service costs;
2. Costs borne by patients and their families;
3. Costs borne by the rest of society.

Table 2: Cost components to be considered in the economic evaluation of health care programmes

Cost	Cost Type
1. Health Service Cost	
Labour costs	Direct
Non-labour costs	Direct
Capital costs	Direct
Overheads	Direct
2. Costs borne by patients and their families	
Travel costs	Direct
Out-of-pocket expenses for carrying activities	Direct
Production losses	Indirect
Pain	Intangible
Anxiety	Intangible
General unpleasantness	Intangible
3. Costs borne by the rest of society	Indirect

In general, the categories presented in Table 2 include all types of costs described before, being the costs of health services direct costs (fixed or variable), the costs borne by patients and their families can be direct, indirect or even intangible.

The costs borne by the rest of society are those not directly linked to the intervention, being indirect costs. Finally, a note on an additional typology of costs: overheads. Overhead costs are shared costs because they serve several different departments and programs. For example, the costs of electricity, services of general administration, the clinical file, the laundry or cleaning services and maintenance, etc. Despite the difficulties that may arise in the computation of these costs they should be estimated and, therefore, it should be found a common unit of measurement, a cost driver (e.g. the number of patient-care hours health services provided by the wardrobe) of their use throughout the health program.

A better treatment of overheads in health care environments ask for more sophisticated cost-accounting systems, such as activity based costing (ABC) - see, for example Ross (2004). Traditionally, in hospitals overhead costs have been divided by a volume-related base (e.g., the total number of treatments or patient days). In an ABC model costs are estimated by using multiple cost drivers. Thus, resources are allocated in terms of resource consumption by the different cost objects (patients, treatments, etc.). There are some studies on this approach in hospitals. Several studies have been trying to apply ABC to healthcare organizations. It will help healthcare organizations to avoid suboptimal or even wrong decisions (e.g. Cardinaels et al., 2004; Chang, 1993).

The question or problem is how to measure and value these costs?

The knowledge of the cost structure of a health institution is very important for a better management of the services and for the rationalization of resources, thus allowing the decision maker to use cost information to support the process of planning for the medium and long term. In health care programs it is necessary to measure not only the quantities of resources used, as well as their prices or unit costs. It is relatively easy to measure the amount of resources consumed in a health care program. However, the same can not be said about the prices. Do we have the necessary and sufficient data that allow us to allocate with accuracy the costs to the different health care programs? Is the price a proxy for the costs? Total costs are thus obtained by the product of a vector whose elements are the quantities of resources consumed on average per each case (e.g. the number of hours worked by health professionals, the number of times per minute that the equipment is used or the number of patients treated) by the vector of their unit prices. The measurement of costs implies the determination of the cost elements associated with each alternative therapy.

The valuation of resources should be made based on the concept of economic cost. Although it is considered more appropriate to use the opportunity cost, in practice, they are used market prices. Prices are the "signs" that allow consumers to make their choices in accordance with the marginal benefit associated with each option. However, there are resources for which there are not market prices.

Despite the undeniable usefulness of the price as a criterion for estimating and assessing costs, the price of goods in general and the resources consumed in a given health program, in particular, may not reflect the true costs spent on them (e.g. due to the lack of information on costs or to its inaccessibility). It is therefore crucial to take into account in an economic evaluation of a health program, that prices do not always reflect the true costs and that it is necessary to have some caution when using pricing as a proxy for the costs. Drummond et al. (1997) argues that market prices may not reflect even the true opportunity cost due to the imperfections of the health market. There are several studies that demonstrated this aspect. Cohen et al. (1993) showed that prices of cardiac procedures are substantially different of the related costs (due to the reconciliation between the costs of services and prices charged by hospitals), although the relationship between the various procedures there is not substantially changed. Thus, it could happen that the price generated by the market or does not match the actual cost for being funded or because there are taxes that distort its value. When we face these conditions, it is necessary to examine the shadow price through techniques of cost accounting analysis. However, the greater the fluidity of the market, the greater the chances of the prices that

prevail in it are closer to opportunity costs. However, when this is not possible, it is necessary to use the aforementioned shadow prices.

COST ANALYSIS METHODS IN HEALTH CARE SERVICES

The measurement of costs is similar regardless of the type of analysis being undertaken. Resources consumed can be divided in a number of different ways. For example, Robinson (1993) used the classification of direct (staff wages), indirect (for example, loss of income due to illness), and capital costs (investments in buildings), but costs may also be divided into those borne by the National Health Service (staff, hotel services, drugs), those borne by the patient and family (for example, travel), and costs to the rest of society (for example, health education).

However, the real cost of any health care intervention is the loss of health outcomes from other programs that have been forfeited by putting the resources in question into the first program, this is known as the "opportunity cost". Opportunity costs rest on the two principles of scarcity and choice. Scarcity means that societies do not have enough resources to meet all their citizens' desires. As a result of scarcity, choices have to be made as to which activities a society should undertake and which should not be undertaken. Opportunity cost is of major importance to the economist and the aim of economic evaluation of health care services is to ensure that the benefits of the programs implemented are greater than the opportunity costs of such programs.

Cost evaluations can be divided into four basic approaches (Drummond, et al., 1987) and Robinson (1993):

- 1- cost-minimization analysis,
- 2- cost-effectiveness analysis,
- 3- cost-benefit analysis, and
- 4- cost-utility analysis.

Each approach has a well-established methodology, but there are still a number of important technical issues that must be considered when evaluating the conclusions of these studies; particularly how uncertainty is handled and the time frame of the evaluation. Uncertainty in the analyses is almost always addressed by performing a simple one-way sensitivity analysis that varied individual parameters on a one-by-one basis over a range of values to determine what effect this had on the overall conclusions.

Cost-Minimization Analysis (CMA)

Cost-minimization analysis (CMA) is used when the outcomes of two procedures being compared are proven to be the same (for example, day stay or overnight stay treatment for removal of impacted third molars). The

aim is usually to find the lowest cost program. It may be included as a form of cost-effectiveness analysis.

Cost-minimization analysis is the simplest cost-evaluation method. It takes therapies with equal efficacy and compares their costs. Ideally, this should include all aspects of the costs of therapy, including acquisition, storage, administration, and monitoring costs.

In the cost minimization analysis, if there are results which prove that health outcomes of the new therapy are equivalent to or better than the actual therapy, then only cost will be analyzed. However, all costs associated with the new therapy should be considered (costs with new drugs, complementary treatments, etc). Usually, the new approach is more effective but also more costly. When overall costs are higher, benefits and costs should be balanced.

Cost-Effectiveness Analysis (CEA)

Cost-effectiveness analysis (CEA) is the most widely used method of economic analysis until the 1980s. This method allows us to answer the question 'Given that it has been decided that this type of health care will be provided, what is the best way of doing so?'

Cost-effectiveness is used when the programs may have differential success in outcome, as well as differential costs. The outcomes vary but can be expressed in common natural units such as 'life years gained' or 'blood pressure reduction' and cost-effectiveness is normally expressed as cost per unit effect. A useful technique for comparing alternative programs whose effects are measured in the same units but cannot be used to assess an isolated single program and it is not possible to compare interventions which have several types of clinical effects. It was this disadvantage that lead to the development of cost-utility analysis (CUA).

This methodology involves calculating the costs of different therapies that achieve different clinical outcomes and comparing these costs on the basis of the cost to achieve a particular outcome. The difference between therapies is often expressed as the incremental cost-effectiveness ratio, that is, the additional cost to achieve a better outcome.

If any alternative dominates the others, the decision maker needs to compute the costs of the additional health provided by the different alternatives. CEA is centred on a single outcome (e.g. reduced mortality) and presents the incremental cost of each incremental benefit. For example it can be estimated the cost per year of life gained as a result of a new treatment. The focus on a single measure is the major limitation of the CEA approach.

Cost-Utility Analysis (CUA)

Cost-utility analysis (CUA) should be the method of choice when quality of life is either an important outcome or the important outcome. This is the ideal method when the intervention affects morbidity and

mortality or when treatments have a wide range of different outcomes and a common unit is required.

This approach is said to lie somewhere between cost-benefit and cost-effectiveness analysis. 'Utility' is a term used by health economists to refer to the subjective level of well-being that people experience in different health states. Utility-based measures are usually expressed in terms of quality adjusted life years (QALYs) which are weighted utility values. Information from QALYs, along with costs, can be used to guide resource allocation.

Cost-utility analysis is becoming the most widely used form of cost evaluation for new therapies. It is essentially a subtype of cost-effectiveness analysis but uses utility to measure the effectiveness as a way of comparing therapies in different disease areas or therapies that achieve different types of outcomes within a disease (e.g., increased exercise capacity vs. reduced exacerbation rates). The commonest utility used to assess the outcome in these studies is the quality-adjusted life year (QALY). Like cost-effectiveness analyses, cost-utility analysis can also be used to derive a cost-utility ratio, which is the incremental cost of an intervention to achieve one QALY compared with an alternate intervention.

The QALY gain or loss is the equivalent number of fully healthy years of life lost to a disease or gained as a result of a therapy. It is based on the actual number of years gained or lost corrected for the quality of life during those years on the basis of a preference weight ranging from 0 (dead) to 1 (perfect health). For example, 2 years of reduced health judged to be 50% of normal quality will be converted into 1 QALY. There are different approaches to estimate quality weights.

Preference weights are based on utility values that reflect a person's preference for a particular health state. Utility values for a given health state have been measured by using different populations, including samples of the general public, patients with the disease, and clinicians.

All cost-utility analyses depend on the robustness of the derivation of the utility values. As with economic modeling, there has been little work looking at uncertainty in the estimates of utility values. This is clearly essential when considering the results of cost-utility analyses.

Cost-benefit analysis (CBA)

Cost-benefit analysis (CBA) is one of the most comprehensive and flexible methods of economic evaluation which is available. If the outcomes of two health programs differ (for example, comparing hypertension screening with flu vaccination) then a common denominator must be established to allow comparisons of outcome. Cost-benefit aims to do this by placing monetary values on both inputs and outputs, i.e., treatment costs and consequence costs (Kumar et al. 2006). It can look at one health care program in

isolation, although the alternative of doing nothing or continuing current practice is always implied (Donaldson, 1990). May take one of two approaches: the human capital approach or individuals' observed/stated preferences.

Cost-benefit analyses calculate the cost of particular interventions and relate these to the cost savings that result from that approach. The time over which costs are spread is an important factor in such analyses. When viewed from the perspective of the whole health care budget, the cost savings can sometimes be virtual rather than real. For example, saving hospital bed days may be very important to allow other patients to be admitted, but rarely reduces overall costs to the health care system as another patient will be admitted to that bed. Nevertheless, this does allow more patients to be treated for the same expenditure and so is a more efficient use of resources.

Cost benefit analysis is a widely method of economic evaluation used by public organizations and in public projects. Nevertheless, its application in health has particular problems and limitations. In this approach, health improvements should be valued in terms of money. Measurement is a crucial and difficult task in CBA and some authors are not comfortable with the use of this method in health evaluation.

Cost-benefit and cost-utility analysis both address the issue of outcome valuation and, therefore, shed more light on whether certain treatments are worthwhile. In contrast, cost-minimization and cost-effectiveness assume that the intervention is worthwhile. However, it is important to realize that none of these analyses can be used to replace sensible judgments, but may be used as an adjunct to decision-making.

Zarnke et al. (1997) studied papers that claimed to use cost-benefit analysis. Of 95 papers that met the inclusion criteria, only 30 (32 per cent) met the definition of a cost-benefit analysis and the majority of the remaining papers were cost comparisons. Interpreting cost comparisons as if they were true cost-benefit analyses makes communication between health care researchers and policy makers very difficult, and may have detrimental consequences when resources are allocated.

CASE STUDY

The hospital under study serves over 300,000 inhabitants. This hospital offers several services to its patients, within the various hospital activities (emergency, outpatient, day hospital, inpatient and surgical activity), including three intensive care units fully equipped with advanced technology. This hospital, with a capacity of 539 beds, mobilizes approximately 70,000,000 Euros per year from the financing program of health care established between the hospital and the ARS North. In 2010, the hospital had 154,000 emergency episodes, 253,000 outpatient visits, 24,000 patients left the

hospital, 18,000 sessions of day hospital and 12,500 surgeries.

Table 3: Hospital Activity in 2010

Emergency episodes	154.000
Outpatient visits	253.000
patients left the hospital	24.000
Sessões de hospital de dia	18.000
Surgeries	12.500

These figures show how important is to control the hospital budget. Indeed, despite being considered as of average size for financing purposes this health care unit has a high activity level. Furthermore, beyond the funding allocated to the institution through the state budget, only a very small portion of the revenue of the hospital is obtained from user fees since they are increasingly granted exemptions. On the other hand, financing from third parties from specific subsystems which generate additional funds is also decreasing. In this sense, it becomes important to assess investment decisions and define the impact of economic and financial decisions.

The economic evaluation of health care services is still very underdeveloped in terms of cost analysis to compare alternative solutions. Moreover, the need to obtain immediate reduction of expenditure and operating costs is often conflicting with the need to determine costs in order to settle the effectiveness of adopting a certain strategy and investment priority. On the other hand, it should be noted that indirect costs, as it happens in most organizations that are service providers, constitute a substantial portion of total costs. In this context, cost breakdown and a detailed analysis and allocation of indirect costs is very important

Cost-Benefit Analysis: Complementary Diagnosis Means

Even though they are still clearly insufficient, the Hospital has been performing some economic evaluations, particularly in terms of investment projects, among which stand out the inner realization of supplementary diagnostic versus the contracting of outside companies for these services.

Outsourcing in the area of additional means of diagnosis is on hospital's agenda and, given the increasing number of tests prescribed and the amounts involved, it becomes necessary to produce economic evaluation studies of these two options, which can be seen in a purely financial or economic perspective given the additional costs that the patient, family and society itself will have to bear if tests are conducted abroad, particularly in terms of travel and other associated costs, the loss of working days, etc. These costs are considerable because these third parties, generally, are not so well located as the hospital which is in the city center. In this hospital, it

was recently established a contract for some Hospital examinations abroad in a private entity located about 15 km from the hospital location. Naturally, this contract offered better financial conditions to the hospital, but the costs for the patient and society have increased. Nevertheless, in the cases that the patient is hospitalized, the outsourcing of medical exams increases the direct costs associated with transportation or as a result of increased hospital days until the arrival of the results which will permit to evaluate the patient's clinical condition. These examples show how important is that the economic evaluation of projects or investments within health care organizations should always be based on a cost-benefit evaluation, taking into account the direct costs arising from the acquisition of new equipment and human resources, the unit cost per day of hospitalization, the increase of activity consumption (e.g. more hospitalization days), and well as indirect costs borne by the patient in the displacement and loss of working days, which are also costs borne by the society as the result of production losses.

Cost-Utility Analysis: New Technologies for Coronary Artery Diseases

Another situation that deserves an accurate economic evaluation is the use of new technologies in heart diseases and/or heart failure or sudden death. Heart diseases currently represent the second leading cause of mortality, with an increasing prevalence of diseases such as myocardial infarction and sudden death. This is due to unhealthy lifestyles.

The Hospital has been developing the application of several therapies associated with these diseases namely, the implementation of medical devices - implantable pacemakers and cardiac defibrillators (ICDs). The application of this therapy follows a set of phases: conducting a first appointment for a baseline assessment and prescription of the necessary examinations, with the level of examinations closely correlated with the need of an improved diagnosis, subsequent examinations and analysis and the preparation of the intervention; performing the surgery, hospital stay of 24 to 48 hours, follow-up of consultations and possible revision or replacement of the medical device.

The final cost of this therapy depends from the performance of the proposed plan, and reflects mainly the direct costs associated with examinations, the staff costs that ensure consultations and examinations in hospital, the medical device and consumer costs associated with the hospitalization and the surgery. The hospital spends on average about 2,000,000 Euros per year just in the acquisition of medical devices. Only these costs, i.e. associated with the consumption of these devices, can vary between 1,000 and 30,000 Euros per patient, depending on the needs of each patient, which influence the technical choice of the device that should be applied. In spite of the constant technological

development, the medical devices industry is still not very competitive being concentrated in a small number of companies and prices are relatively high. Given the costs associated with the application of this therapy, the hospital should assess the results of its implementation? Which are the costs imposed to the society by the application of this therapy to patients with 80 or 90 years old?

While new technologies enable significant improvements in terms of diagnosis and therapy in many clinical situations, when applied to most patients, the marginal benefits resulting from its use tend to be small or zero. This occurs because consumers have a bounded rationality which limits their ability to rationally evaluate the increased utility of a new device or therapy. On the other hand, the producer uses technological innovation to develop new products and to raise prices and income generating situations of technical inefficiency and sub-optimal allocation of resources. The cost-utility analysis seems, in this case, to be an appropriate model to assess the impact of the results of this therapy, as it evaluates the quality of life achieved and the life years gained by the implementation of the medical device. Thus, the value to society would be equal to the sum of the health benefits it produces. Indeed, the costs associated with this therapy, which are very high and weigh the hospital annual budget, must be reflected in benefits to the society and to the patient. A cost-benefit analysis or a cost-effectiveness analysis (e.g. the reduction of the mortality rate?) could also be applied by the Hospital to assess the application of these medical devices. Furthermore, in this case they should be also considered the intangible costs, e.g. losses in terms of welfare associated with the probable death, disability, dependency, anxiety, pain and discomfort

Ambulatory Surgery versus Conventional Surgery

Nowadays, the economic evaluation on outpatient surgery versus conventional surgery demands is particularly relevant. In fact, cost control and reduction of costs associated with the hospitalization became the main objectives of ambulatory surgery. Any of the four economic assessment methodologies could be applied to this analysis, which is based essentially on reducing the costs of health services in terms of costs per patient day, once the outpatient surgery is performed up to 24 hours and therefore does not require hospitalization. In addition, all hospitals now have an incentive for compliance because the financing program sets a goal for the percentage of outpatient surgery in terms of the total of surgeries performed. Since the last two years, several efforts have been developed by the Ministry of Health in order to promote this type of surgery. Many hospitals have received financial support to create autonomous ambulatory surgery units with specific human resources. Since, ultimately, the decision to choose between conventional surgery or outpatient

surgery is always a clinical decision, the fact remains that the costs of health services and the costs borne by patients, their families and society are significantly reduced in ambulatory surgeries.

Diagnosis Related Groups

The data sources for the measurement of hospital costs can be varied, namely: administrative databases, surveys made to the population, primary data, data from the hospital information systems, cost accounting, price lists, among which is included the ordinance number 132/2009, from 30 January, i.e. the table of prices of Diagnosis Related Groups (DRGs) and medical interventions.

The DRGs is a classification system used to classify hospital cases into a group of interventions which consume an equivalent amount of hospital resources. It is used to support a general payment and funding system. These Groups are defined to be consistent in terms of similar patterns of resource consumption. The implementation of this system of classification of patients in Portugal intends to develop a costing model for the Portuguese hospitals and the use of the DRGs for managing purposes.

The precise calculation of average costs of each final product or service (patient treated) would require the estimation of actual costs with the integrated treatment of patients in each DRG. Since the data available from the cost accounting system in Portuguese hospitals did not allow calculating directly their value, costs have been estimated for each DRG from its division into two main components:

- a) costs that are relatively independent of the length of stay (e.g. costs related to laboratory, radiology, the operating room, to pharmaceuticals, medical consumables and intensive care units);
- b) other costs directly related to the length of stay (e.g. costs derived from medical care, nursing and other personnel, facilities occupancy).

Therefore, prices (which are measured as average prices) are calculated based on average costs of hospitals directly or indirectly involved in the treatment of the patients, admitting the existence of different prices by groups of hospitals that have some similarity in terms of their infrastructure and service-mix. The average costs of the various Portuguese hospitals is determined annually through the information produced by the different hospitals. Not always every year but with some regularity and based on this data, the ordinance is updated in terms of the prices for the different medical procedures and DRGs.

Therefore, from the ordinance we can collect interesting information: the price of internment, the price of outpatient surgery, the price of day hospital sessions,

consultations, emergency interventions, home care services, etc.

DISCUSSION

The costs of treatment may be inferred through information provided by the cost accounting system, which allocated costs to cost centres according to the Cost Accounting Plan for Hospitals, or through information obtained in the information system of each department or area of activity or, finally, based on the prices defined by the Ordinance for medical procedures and DRGs.

Should also be noted that the Activity Based Costing (ABC) has been described as the most efficient method to measure the costs of services, since it allows viewing the expenses incurred at each stage of production process, thus enabling the knowledge of the real costs of activities. However, the implementation of an ABC system requires a high financial and organizational effort, particularly in restructuring the hospital information system.

Cost information is particularly important to determine the amount of resources consumed. However, the information produced by the cost accounting system, those from the ordinance or data from the several healthcare information systems is effectively useful to measure costs supporting accurate economic evaluations of treatments and health care services?

As already stated, the price generated by the market does not always reflect the real cost of goods. This happens because the health care market is particularly complex and specific.

In Portugal, the prices of DRGs and medical care are often used to measure the costs of the services. It is assumed that the National Health System is regulating the market knowing the relationship between the amount of resources consumed and the social benefits obtained. Nevertheless, these figures reflect considerations (Administrative and Budgetary) that have nothing to do with market mechanisms.

In fact, most components of DRGs are set by political decisions and the willingness to pay a certain price. It is always very difficult to obtain real and reliable information on patient's costs in a hospital. Considering an average cost per day according to the average hospital stay is a methodology that is clearly insufficient and it stays below the expectations. Patients in different conditions may have the same costs simply because they were admitted to the same service during the same time. This may constitute a bias in economic evaluation when a particular treatment reduces, for example, the average working time of doctors or other health professionals. Likewise, the average cost of any medical procedure or any episode in which substantiates the hospital activity (e.g. outpatient treatment, emergency episodes, hospital day session) should be determined with accuracy and

according to an analysis of all the resources effectively consumed.

Indeed, the prices fixed by the ordinance say little about the costs of services rendered to the patient. Furthermore, when health care is financed directly by a global budget, information about health care services by patient is not always available. There are, however, advantages in using DRGs to set hospital costs. They are, after all, specific, comparable, relatively reliable and break down into several components.

The usefulness of DRGs may, however, vary from country to country depending on how they were constructed and used. In general, they have been used solely as information for funding purposes. When used as a source of funding, DRGs are useful for economic assessment exercises, as they represent the amount of resources used. Nevertheless it lacks some value in that it represents a cost per diagnosis that is not directly related to the hospital budget.

CONCLUSIONS AND FURTHER RESEARCH

In this article it was showed situations that can be analyzed in light of several methods of cost analysis applied to health care services. We discussed the need for better costing systems and cost information based on more sophisticated costing models such as the ABC in order to support a better economic evaluation of hospital services. The use and implications of DRGs were analysed with particular detail.

It was noted that the price of each DRG does not reflect the actual use of economic resources. If the hospital's budget increases, the unit price for each DRG and, as such, the totality of DRGs, will also increase. However, there was not any change in the volume of resources used. Furthermore, in this context, prices are independent of the efficiency of each organization and the same product will have the same price. Strategic decisions in health care organizations depend on this price mechanism, but it may contain systematic errors. Thus, if the relative value of the different DRGs (i.e. its price) is changed or corrected, previous strategic choices and assumptions could be questioned, forcing organizations to make deep reformulations.

In this sense, it is necessary, and even recommended that when DRGs are used as a source of information for economic evaluation, we keep in mind that these values are not real market prices because they may not reflect correctly the opportunity costs. Therefore, we must pay special attention when they are used to make national and international comparative studies. Indeed, it is vital to stress that it is necessary to exercise caution since DRGs differ significantly from the real opportunity costs. Even, if they are still one of the privileged sources for cost estimation in hospitals.

Alternatively, the costs calculated through the application of the economic evaluation models may contribute to a better understanding of the unit cost of

each medical procedure or episode. This information should be complemented with the use of more sophisticated costing systems such as the Activity Based Costing.

So there are opportunities for further work in order to seek the most convenient way to apply the various methods of cost analysis in health care services (cost-minimization analysis, cost-effectiveness analysis, cost-benefit analysis, and cost-utility analysis) as well as methods of accounting and cost allocation as well as the design of sophisticated costing systems that support better economic evaluation in a hospital environment, in particular, and in health care services in general.

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AN ACTIVITY-BASED COSTING MODEL FOR STRATEGIC DECISIONS IN TRANSPORTATION ON DEMAND PROJECTS

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ABSTRACT

Today there are many people who lack access to adequate means of transportation (people with reduced mobility, elderly, people in rural areas of low population density, etc.). In these cases the conventional solutions do not serve and tend to worsen due to increased costs of private transport and the reduction of conventional transmission lines at these sites. In this context, emerged alternative transportation models called "transportation on demand".

However, although there are some experiments, these new models are still not consolidated due to problems of technical and economic. Beyond the technical aspects necessary to develop cost models suitable for designing a system with economic viability and to set prices and pricing policies that ensure the attractiveness of the service without compromising their economic viability (namely with recipe above cost). The complexity of this system and the relative weight of significant indirect costs justify the application of a costing system based on activities. In this article we present a cost analysis based on the strategic ABCM model to discuss the conditions of economic viability of a transport on demand system applied to the municipality of Terras de Bouro. These results are important to support strategic and operational decisions.

INTRODUCTION

The rural area is a region where population density is low with a tendency to continue to decline. People migrate to urban areas where they find better infrastructures and services which meet their needs. A consequence of this move is the reduction in the supply of products and services in rural areas due to reduced demand. The operating model of the traditional public transport is inadequate for rural areas (Brake and Nelson 2007). Traditional line transportations need to transport a certain minimum of people daily to be viable. Thus, operators have been abandoning lines and services in rural areas. In this context, the rural areas tend to fail in

terms of collective public transportation service, forcing people to use individual vehicles.

Thus, it is important to explore alternatives to conventional public transport in rural areas and areas with low population density. These alternatives must be more effective and more responsive and they should meet the needs of specific mobility. These alternatives do not require schedule, route or fixed stopping, or vehicles of a certain capacity but a service adjustable to users' needs. In this context, emerged a new concept of public transport characterized by dynamic routes and free of any fixed schedule, which can be adjusted to the needs of users, called "transport on demand" or DRT (demand responsive transport).

The transport on demand requires a strong technological component and the integration of several technologies, being this aspect a key factor for the system efficiency. Furthermore, a good communication system is fundamental to satisfy the needs of the users. For example, to know the real needs of the users, it is necessary to have a constant and effective communication between the system and the users (Frosini et al. 2004). The planning of the routes, which are calculated on a daily basis to meet demand assessed for each day is another complex and critical aspect in a DRT system. Indeed, route planning is considered "NP-hard" problem. In this article, it is presented a cost model that will assist in the calculation of tariffs or tariff models, the analysis of routes and transport lines profitability, the analysis of customer profitability and, ultimately, the analysis of viability conditions of the on the demand transport system itself. This cost model will be important to support strategic and operational decisions in terms of the design of the DRT system. To accomplish this purpose it is suggested the use of an activity based costing system, particularly the strategic ABCM (Kaplan and Cooper, 1998).

The transport on demand is an intermediate solution between the taxi (individual transportation) and the bus (public transport). Thus, it cannot be applied a bus fare or charge the price of a taxi. But how much should a customer pay for the trip? How to calculate the cost of transporting a specific passenger or the cost of satisfying a specific request? The fare should be a hybrid model, namely, with a variable fare starting from a value basis?

On the other hand, the system must be attractive to the customer through a price acceptable but must be financially viable. Total costs must be lower than revenues. Eventually, subsidies for the promotion of people mobility in low income social groups, or with limited mobility, etc. can be considered.

This paper is structured in six sections, including the introduction. Next section discusses the concept of transportation on demand. The third section is related with the designing of the DRT system. The fourth section focuses on the main concepts behind a strategic activity-based cost management system. The fifth section discusses the conditions of economic viability of the transportation on demand system applied to the municipality of Terras de Bouro. The final section presents the main conclusions and suggests opportunities for future work.

TRANSPORT ON DEMAND

Traditional systems of public passenger transport offer services with schedules and routes predefined. In general, these systems are suitable for patterns of high and concentrated demand, but often become inadequate when demand patterns are low and scattered. The problem consists of design a system of public passenger characterized by a high transport flexibly that responds to real-time demand. During the last decade we have been assisting the appearance of alternative systems based on flexible services rendered in terms of schedules and routes permitted, which are created according to the actual needs of the population, reflected through explicit requests for travel. For example, the service as Personal Bus Tuscania (energie-cites, 2002), the AGATA project (Frosini et al. 2004) which involve four countries (Italy, Spain, Portugal and Morocco), or collective taxis in Beja (Portugal).

However, these systems ask for greater requirements in terms of operations management, given their complexity, usually requiring the use of advanced information and communication systems, including automation of order fulfillment and dynamic route planning (Oliveira, 2010). The planning system consists in the optimization of a number of vehicles which pick up passengers from a point and delivery them to another. This issue is considered a vehicle routing problem with pickup and delivery (VRPPD) (Xiang et al. 2006), a specific case of VRPPD is the dial-a-ride problem (DARP). The DARP have been focused on humans and in time windows. Thus, in this case, planning is essentially solving a dial-a-ride problem.

One of the first studies on the characterization of route planning problems of goods and people was developed by Bolin et al. (1983). This study is still considered an important reference because the amount of problems they tackled. The article includes the classification and categorization of the problems of route planning and programming, a review of algorithmic techniques and solution methods, and an overview of key applications

and implementations known. Optimizing VRP arrives at a computational complexity too high namely, because the variable number grows exponentially. Therefore it is categorized as an NP-hard problem. The way to reduce that complexity is typically the use of heuristic methods, which significantly reduce the computation time but, instead, the solution may not be optimal (Oliveira, 2009).

The transport on demand is directed to users needs, without being subject to any or all of the following obligations: travel, location of bus stops and fixed schedules (Carvalho et al., 2005), using for such small/medium-sized vehicles and operating modes shared according to the needs of embarkation/disembarkation of passengers (energie-cites, 2002). An effective way to ensure this service is the integration and interaction with customers and the central coordinator, based on some form of information technology and communication (Frosini et al. 2004).

For the communication between the system and the users there are several alternatives but the trend is to foster widespread use of mobile devices. The use of mobile devices with Web access is very common nowadays. Therefore, it is expected that the fraction of users of transportation on demand, owners of such technology, can become significant in the medium term, even in rural areas. These devices require a small application with user friendly interfaces and easy to interpret images, and also have filtering mechanisms to reduce the elements on visualize through the selection criteria (Motos, 2007). Applications that work directly to the SIGs have features that determine the level of detail and content appropriate to send to this type of devices.

Several software systems could be used to manage paratransit services including Trapeze, RouteMatch, Stratagen and Ecolane. Several activities should be developed such as dispatching, scheduling and reservations. Software programs enhance the “real-time” performance of dispatch and dynamic route planning, and provide to passengers up-to-the-minute schedule information. Furthermore, GPS technology can be used to help these purposes. On the other hand, route designs should be flexible to accommodate fluctuating demand. Specific software can monitor real-time performance giving to dispatchers and managers tools to take action in real time in order to optimize routes and to ensure that there are the right number of vehicles on the street at the right times. For example, if a passenger is not ready when the bus arrives or the bus is late, customized tools enable dispatchers to re-structure the remaining pickups accordingly.

There are two different models of transport on demand: transportation on demand in areas of low population density (this is the case presented in this article, referred to as DRT) and transportation on demand in areas of high population density, but for certain specific market. The first applies in particular in rural areas, the second

model is oriented towards urban areas. The DRT will be explained in more detail in subsequent sections.

Paratransit services are transportation services for people unable to use regular public transit. These services ask for advanced technological solutions to improve dispatch, route design and operational coordination and back office services to manage call centers and dispatch software. Customers of these services are not able to pay expensive tickets. Thus, these services should run very efficiently. To improve efficiency some companies use taxicabs in low activity periods and route deviation in low density areas. For example, Veolia manages 250 paratransit operations around the world holding 5 Key paratransit contracts in the USA. In these cases, a rigorous management of costs is crucial. Reservation changes and no-shows must be taken into account in these services. The trade-off is between routes which must be optimized for cost efficiencies and acceptable wait times which ensure passenger satisfaction.

DESIGNING THE SYSTEM

In the designing of the support system it is important to understand how the data flows since the intention to travel to the moment when travel details are returned to the system user (i.e. the passenger). Moreover, there are several strategic choices that the service provider should adjust in order to fulfill customers' needs and company's economic results. In this process there are four main aspects which should be taken into account for the designing of the system: the Management of the Requests, the Planning of the routes, the Communication with the Users, and Strategic Decisions.

The Management of the Requests

The first step depends on the user and involves making a request for mobility. The users have different ways of doing it. They can dial directly to the central coordinator to register their request and wait to be informed about available possibilities. This approach is limited by the operating hours of the service and it is directed to people who are not familiar with the system or not have access or knowledge that permits the use of the other available technologies. Another alternative to request a transportation service is to make a request through the messaging system (SMS). The request must be submitted as a message written with all data, but mostly in a uniform and correct way, i.e. a standard structure should be followed.

The web portal is another way to make the requests for this mobility solution. The web application should be user-friendly and also have relief camps to help filling the required fields correctly. The site will require registration by customers in order to ensure privacy and security of customer data. Registration is a unique identifier, allowing each to perform and see a set of data and information about it.

The requests will be stored in the server until the planning stage. A request may be modified or canceled during the planning stage, but not after the planning stage, because it may modify a planned route. A change in terms of time schedule may cause impact in other customers and if it implies a violation of the time window of other clients they can no longer travel. It may be a company policy to charge the customer in these situations. Thus, in this first step customers can make changes or cancel demand.

The Planning of the Routes

Planning is a central problem in a transport on demand system, because of the need of calculating the daily route that each vehicle should do. The problem to be solved is NP-hard problem, namely with the increasing number of requests the number of variables to consider in the formulation grows exponentially. Therefore, the time needed to achieve a solution may be so high that it exceeds the useful time, namely the computation time be greater than the acceptable waiting time.

So, often the option is to use a heuristic to performing the planning. Not being the best solution, this approach solves the problem in a useful time with an acceptable good solution. Another factor to take into account in the planning process is to know when the system should start planning on the basis of the requests made. The number of requests directly influences the calculation time of the routes and limits the possibility that customers have to modify their requests. There are several assumptions that characterized the model which result from a strategic choice that can be modified over time.

The Communication with the Users

After calculating the route it is necessary to communicate the results to service users and motorists. This communication depends on the communications and the technologies available for the users and for the motorists, and in this last case of the existing technologies in the vehicles. Users can be informed via text or voice message. Users can set the time when they want to receive the information. The web portal information is updated in terms of schedules and routes after the planning.

During the service execution, the operational center may receive information from vehicles depending of the available technology. However, there is important information that will be always available particularly, times of arrival and departure of the vehicle at each stop and full details of requests that were satisfied.

Strategic Decisions

In the communication between the customers and the system, firstly, and between the system and the customers, after, arise several problems such as sending correct data when carrying out a new request; particularly, the presentation of a valid and useful contact. It will be through this contact that the

communication between the system and the client will be done. Another problem occurs when customers are not able to use the available technology which will be an obstacle for the use of the system. Which strategies can be pursued to solve these problems?

With regard to the policies of flexible transport service, time windows length affect the system's flexibility, since the time windows of each request must be fulfilled. Thus, the shorter the time window is, the lower the system flexibility is.

But, there are more aspects that determine the degrees of freedom of the service provider and users. Reducing the level of flexibility of the system facilitates the convergence of system solutions for greater technical and financial viability. The most flexible system in terms of picking/delivery is one in which the stops are the users' own homes, i.e. a door-to-door service. A system less flexible is those who use the bus stop of the traditional transportations lines. From a practical perspective, flexible transport services can be designed assuming intermediate stops which are not the homes of the service users but which are not the traditional bus stops. Instead, stops will be locations preset by the planning system and the customers.

On the other hand, there are other strategic decisions that affect the fleet flexibility and subsequently the flexibility and the viability of the entire system. Firstly, vehicle capacity because the larger the vehicle the lower the flexibility of the system. The availability of each vehicle also influences the definition of the different routes. It is necessary to take into account which vehicles and motorists are available for travelling in each planning moment. The flexibility of the system depends on the number of vehicles available, their capacity and available motorists. The number and type of available vehicles depend on company's fleet, the conditions of having access to leased vehicles, and the combination of DRT services with other transportation services including taxi services and conventional transport. The type of vehicles used will also determine the type of customers who may be served. For example, some vehicles will not be adequate to users with reduced mobility. Some vehicles will not permit the access to certain places or do not will have the comfort desired by some customers, etc. All these questions must be considered because they will have implications on the service provided and on the conditions of the service. Thus, they will define the DRT service in terms of market positioning and customers served. These issues are strategic and should be weighted before the design of the DRT system in order to maximize the probability of success. Strategic decisions are not likely to be changed in the short time, only may revised after each business cycle, i.e. some each 3, 5 years and others in longer periods.

STRATEGIC ACTIVITY BASED COST MANAGEMENT

Strategic activity based cost management is a powerful tool for pricing strategies and for profitability analysis of customers, services and business units. Cost management concepts and tools are particularly relevant in environments characterized by high levels of indirect costs, product or service diversity and complexity and business flexibility. In this context, activity based costing and activity based management emerge as very useful tools to determine the amount of cost-to-serve and to perform profitability analyses.

Activity Based Management (ABM) can be viewed as an extension of activity based costing (ABC) – (Lindahl, 2000) - and they can both be included in the broader concept of Activity Based Cost Management (ABCM). In an ABC system it is necessary to define resources, activities, cost objects and cost drivers. Basically, in an ABC system the cost of a product is the sum of raw materials (and other direct product costs) and the cost of the different activities used to produce it (Shields and Young, 1989; Gunasekaran et al., 1999). In addition, activities are grouped in different levels: unit level, batch level, product or process level, and plant level (Cooper, 1990). The conceptual basis of ABC can be found in Cooper (1988a, 1988b, 1989a, 1989b, 1989c, 1989d, 1989e). The switch from ABC to ABM represents a change in focus, from a cost-assignment view (resources – resource drivers – activities – activity drivers – cost objects) to a process management view (cost drivers – activities – performance measurement) - see Raffish and Turney (1991) and Turney (1992a, 1992b, 1996). Thus, ABCM systems are an extension of ABC and they comprise the use of ABC information for three main applications: product costing, activity and costs driver analysis and the identification of opportunities for improving performance (Raffish, 1991).

In an ABCM system activity cost are attributable to the product in different levels: the unit level, the batch level and in a product support level (Cooper, 1990). *Unit-level* costs occur each time a unit of product is produced or a service is provided (e.g. drilling holes in a component, metal polishing, inspection piece by piece). The occurrence of these activities is proportional to production volumes and sales. On the other hand, *batch-level* activities are developed for each production lot (e.g. a machine to prepare a new production order, purchase of materials). Activities to *support the product* are those designed to allow the production of a particular product or service (e.g. tools and exclusive product testing, technical support for a specific product). Moreover, there are activities attributable to the customer (Cooper, 1990) or *customer support*, which imply going beyond the production perspective. Customer support activities reflect the cost of selling to a particular customer, regardless the quantity and the mix of products and services sold.

Conversely, the ABCM systems are concerned with the analysis of capacity. The rate of inducing activity should reflect the capacity of resources supplied. Measure, create and manage the capacity used and unused is a central element of an ABC system. The fundamental equation is then derived as follows: Cost of Resources Supplied = Cost of Resources Used + Cost of unused capacity.

Resource needs are not only for activities which support the products but also those that support customers, distribution channels and suppliers. Featuring information on the costs of serving different customers can support better decisions, including the following: protecting and growing business with customers that ensure high margins, redefining prices of expensive services based on "cost-to-serve" analyses, offer discounts on cases with a low "cost-to-serve" increasing the turnover, to negotiate the type of relationships firm-clients in order to reduce "cost-to-serve" with benefits for the company and for the clients, abandon customers who are not profitable, seek to attract good customers, etc. "The rule of gold" is that expenditure that is corporate-sustaining, i.e. that one that is made to support the company, should not be imputed to cost objects. However, the imputation of distribution and administrative expenses to customers is important because customers do not consume equally these resources.

An ABC system allows us to understand the costs of serving different customers. These costs should be not imputed according on the amount of sales but they should be imputed in terms of the consumption of resources. Some customers represent high service costs and other reduced costs; there is a set of characteristics that define these types of customers. Both types deserve attention, the former because may be not profitable serve them and the second because if they realize their low cost-to-serve situation may push for lower prices.

It is necessary to understand which factors explain high cost of serving: unpredictability, frequent changes, a too often service, customized products, different logistics, and large demands for activities before and after the sale. It is important to turn unprofitable customers into profitable customers. To do that, the buyer may change the pricing policy with measures taken by the company or in partnership with customers. Customers who are not profitable should be abandoned? Not necessarily, at least in the short term. Nevertheless, if non-profitable customers are not new, strategic or permit to learn something and all the initiatives taken to make them profitable were not successful than these customers should be discontinued and the activities used for other customers. There are several strategies which can be undertaken to increase customer profitability namely, protecting customers who represent high returns to the firm, increase prices of the more expensive services considering the cost-to-serve analysis, offer price reductions to increase sales to customers with low cost-to-serve, to negotiate with clients (cooperating) win-win

strategies which can reduce the cost-to-serve, leave (to competitors) permanently unprofitable customers, seek to win customers with high profitability from competitors.

CASE STUDY

The ASTRA project focuses on three counties in the Portuguese region of Minho, which are Amares, Vila Verde and Terras de Bouro. In this article we will examine the particular case of the municipality of Terras de Bouro, from the three it is the one that has the lowest population density and it fits well the concept of DRT. Moreover, in the county of Terras de Bouro it is possible to clear identify four distinct areas for which there must be a transport solution.

In a survey conducted within the ASTRA project in 2008 found that only 3% of the population used public transportation. Thus, it is considered that the demand for flexible transport service will be at least 3% since in the same survey it was found that a reason for the non-use of public transport is the lack of time consistent with the needs of the population. Thus, it is expected therefore demand rises with flexible transport. Table 1 shows the estimated daily demand for the DRT service in each of the four areas identified for transport in the municipality of Terras de Bouro (zones 1-4).

Table 1: Information on the Daily DRT Service

zone	pass	dist	dur	trip	veh	cap
1	99	25.800	90	9	2	30
2	71	15.100	50	8	1	20
3	11	13.700	45	4	0	20
4	73	8.600	30	8	1	20

The column "pass" shows the estimated demand for each of the 4 zones based on the residents. This number means the total number of passengers carried per day in one direction (namely for or from Terras de Bouro). The daily average distance in meters of each one way trip is indicated in column "dist".

The column dur(ation) represents the total time required to attain a route. In calculating this time it was considered farthest point in each of the zones in relation to the village of Terras de Bouro (considering the column "dist"), the average speed of this kind of service that stands at 30 km/h, a multiplier which reflects the deviations resulting from changes to the "normal" route in order to collect the users in the arranged point, the maximum delay allowed to users and also an additional safety margin for unexpected, adverse weather conditions, etc.

To get the number of trips/day per route in each area (variable "trip") they were considered several aspects including the period of greatest flow, the duration of the trip, how many passengers are transported in average per day in both directions and the vehicle capacity. The number of vehicles and their capacities are presented in the two last columns of Table 1.

The capacity of vehicles which should be assigned to each zone is influenced by the level of demand in the hour of greatest flow, which lies between 7 and 9 am. In this time interval they are performed approximately 60% of travel departures. For zone 1 it is expected that 60 will be transported in the hour of greatest flow, and as the route takes approximately 1 hour and 30 minutes there is a need of 2 vehicles with 30 seats or three vehicles with a capacity of 20 persons. A vehicle with a larger capacity (e.g. 60 people) would be inappropriate given the context of DRT.

An additional vehicle implies high incremental cost (acquisition costs, maintenance, fuel and at least another motorist). Most costs are related to motorists' wages and other related costs plus the costs of acquisition of the vehicle. Thus, they were considered two vehicles with 30 places instead of three vehicles with 20 places. The system optimization is achieved by maximizing the available capacity, namely, take paths with the maximum number of passengers and having the vehicles permanently performing routes.

For zones 2 to 4, routes are shorter, allowing more trips per day. However, there are a minimum number of passengers transported by trip in order to guarantee the economic viability of a route and these areas have less population (see minimum cost/passenger and breakeven (average trip passengers) in Table 4).

Thus, although there is greater availability in zones 2, 3 and 4 they could not be done more trips per day than in the first zone, on the contrary. Considering also that in zone 2, 60% of people are transported between 7 am and 9 am this would be possible making three trips in this period with one vehicle of 20 places. But system flexibility only one vehicle should be enough to make the three trips extending a little the time of the trips and complying with time windows defined by service users. Furthermore, an efficient combination of resources will turn possible to use the same motorist and one vehicle for zones 3 and 4, whereas zone 3 has a low demand level but the routes are relatively short, allowing various combinations.

Motorists will work on average 8 hours per day and considering that the transportation service will be operational from 6:30 to 21:00, they will work in two shifts per day. The calculation of the different routes allowed us to conclude that there are four routes that run concurrently in the morning and three courses during the afternoon. Thus, it will be necessary to have at least seven drivers available daily. Additionally, it is accounted a technician who could, if necessary, replace one driver in specific situations.

The DRT service is characterized by having structural costs common to several areas where the service runs. In structural costs it is necessary to include the costs of informatics for planning and management the routes, administrative costs, marketing expenditures, financing costs, etc.

But firstly, it is necessary to investigate the margins released with the provision of the service in each of the

municipalities under study and analyze the profitability of each transportation line or set of lines corresponding to a "zone". Thus, they were accounted the margins of the DRT service in the municipality of Terras de Bouro, i.e. the overall margin and the margins for each of the four areas defined for the DRT service in this municipality. The tariff plan may adopt different configurations, for example, with a variable component depending on the kms traveled. But, for the cost analysis we just need to use an average fare. After some simulations and considering the price of conventional transportation alternatives, they were considered the following average tariffs: 3.20€ for zone 1, 2.20€ for zones 2 and 3 and 1.75€ for zone 4.

Taking into account these average tariffs and the estimated number of passengers listed in Table 1 the expected annual revenues were computed. The supplies and external services are mainly direct costs of the routes, i.e. fuel and maintenance expenses. Labour costs include wages and other expenses with 7 drivers and 1 technician. Depreciations were calculated for a total investment of 450.000 € in 4 vehicles.

Table 2: Overall Margin for DRT in Terras de Bouro

Revenues	324.974	100%
Supplies and Extern. Services	- 58.410	18%
Labour costs	- 207.200	64%
EBITAD	59.364	18%
Depreciations	- 45.000	14%
EBIT	14.364	4%
Margin	14.364	4%

This margin (14.364 euros, equivalent to 4% of Revenues) was obtained considering only the direct costs of the DRT service in Terras de Bouro. To this margin it will be necessary to subtract the annual cost with the global structure of the DRT service for Vila Verde, Amares and Terras de Bouro. These costs of structure include the costs with the planning and management systems, administrative and commercial costs, etc. They were estimated at an amount between 75.000 and 90.00 euros. Therefore, the implementation of DRT in the three municipalities will be viable if the sum of the 3 margins (before structure costs) is higher than 75.000-90.000 euros plus the cost of financing, if exists, calculated on the amount of funding. The expected level of activity of the DRT service in Vila Verde and Amares is much higher than in Terras de Bouro. Thus, it is expected that the implementation of the DRT service in these three the municipalities is feasible under the conditions of the study presented in this article. However, it is important to mention that the amount of funding and the level of interest rates could derail the operation.

Moreover, it is interesting to examine in more detail the profitability of the DRT service in the Terras de Bouro of the four areas served considering the operating

conditions and the cost model used. To do this, i.e. established the operating margins of the four zones it was used the strategic ABCM model. Table 3 presents the results obtained. Unit-level costs include expenses with fuel and maintenance (these costs are direct costs of each trip) and batch-level costs include labour costs and vehicles depreciation (these costs are costs of running the service in each zone). Service-support costs are general costs to the 4 zones directly traceable to the DRT service in Terras de Bouro, in this case are the costs with the technician.

Table 3: Margins by Zones

	Zone 1	Zone 2	Zone 3	Zone 4	Total
Revenues	164.736	81.224	12.584	66.430	324.974
Unit-level costs	28.805	14.805	6.716	8.432	58.410
Batch-level costs	104.800	63.200	-	63.200	231.200
Unit and Batch-level costs	133.257	73.005	6.716	71.632	289.610
Margin (Zones)	31.479	3.219	5.868	-5.202	35.364
Service-support costs					21.000
Margin (Terras de Bouro)					14.364

Zone 3 complements Zone 4 and both should be viewed in an aggregated way. Zone 4 has the less profitable routes and it has unused capacity used to serve passengers of Zone 3. Independently Zones 3 and 4 are unprofitable but running both results in a positive contribution margin (666 euros).

On the other side, appear routes in Zone 1. This one is the most profitable group of routes even having more costs (more expensive vehicles, more fuel expenses and more labour costs). This shows that the DRT service is more profitable in long and medium-sized courses than in short courses because several reasons. Firstly, in short courses the tariff applied will be reduced and revenues will be lower. Secondly, batch-level costs are so high that transporting a reduced number of passengers is not profitable. Thirdly, if distances are shorter we are pushed to suggest more trips by day in order to transport more passengers.

However, there are a maximum number of possible trips by day which is not so different for short and long distance routes (see Table 1, Zones 1, 2 and 4 have similar number of trips per day, 9 and 8). Thus, in this case, augmenting the number of trips by day will increase costs not revenues. Particularly, it will increase unit-level costs but not revenues. Thus, ticket price, distance and passengers/day are three important factors in the profitability equation of DRT services; and all three are positively correlated.

Furthermore, Table 4 presents additional calculus to complement this discussion. These figures are in a day basis.

Table 4: Cost analysis by Zone

	Zone 1	Zone 2	Zone 3+4	Total
cost/day	512,53	300,02	301,34	1.113,88
cost/trip	56,95	37,50	25,11	
cost/passenger (minimum)	1,90	1,88	1,26	
breakeven (passengers by trip)	18,00	17,00	14,00	
capacity (passengers/day)	270,00	160,00	240,00	670,00
used capacity (passengers/day)	198,00	142,00	168,00	508,00
unused capacity (%)	26,67	11,25	30,00	24,18
unused capacity (€)	230,40	39,60	152,10	422,10
sales/day	633,60	312,40	255,50	1.201,50
ticket price (on average)	3,20	2,20	1,81	2,37
cost/passenger	2,59	2,11	1,79	2,19

Table 4 shows that zones with shorter routes have more available capacity because it is possible to do more trips by day (Zone 1 uses two vehicles, i.e. 135 passengers by vehicle). However, small distance routes ask for a better use of the available capacity because revenues by passenger are lower than in long distances routes (average ticket price is lower). In extreme cases, very short routes should be replaced by a car convenience service (e.g. combining DRT services with taxi services).

CONCLUSIONS AND FURTHER RESEARCH

Rural areas have no regular public transport that can meet their needs. This is basically due to the cost of having lines running without a minimum of passengers. Thus operators seek alternative systems for public transport in low density areas. In this context, the flexible transport comes as a new paradigm for collective public transport. It can be an alternative in terms of effectiveness and efficiency responding to customer needs.

In this paper a cost analysis of a DRT system was performed. One of the three municipalities where the DRT system can be tested was analyzed in terms of costs and profitability. They were identified and analyzed four areas or zones for the DRT service in Terras de Bouro. Results defined a set of important variables which should be taken into account if the service is implemented in this area. Particularly, ticket price, trip distance and passengers/day are three important factors in the profitability equation of DRT services; and all three appear to be positively correlated.

It was found that the less costly line is not necessarily the most profitable. This was the case of line or Zone 1. This line has more costs but it generates high revenues. These results suggest that the DRT service is more profitable in long and medium-sized courses than in short courses because several reasons as it was

explained in the previous section. On the other side, it could raise the issue of making more trips to increase revenues, but it is not justified when demand is low. In these cases the additional revenue generated can be less than the cost of the new route. Furthermore, there should be noted that the most profitable itineraries are those in which the occupancy rate of vehicles is greater. Thus, it makes sense to have a daily planning of the routes that maximize the occupancy rate.

These results show how important certain operational and strategic decisions will turn the service more effective and efficient in order to ensure the economic viability of the DRT system.

For future work it is expected to extend this cost analysis to the other municipalities, as well as to make an integrated analysis of the three areas exploring the links between the municipalities. Furthermore, additional data collection and simulation tools will permit to make more detailed cost analyses. Particularly, the analysis of different levels of demand, considering real places of origin and destination, simulation of various scenarios for the DRT service (variation in demand, number of vehicles, vehicle's capacity and flexibility of temporary windows, etc.). Strategic activity-based costing is a very useful tool for the understanding of costs and revenues as well as to perform profitability analysis, to define price strategies and to support operational and strategic decisions.

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STRATEGY FOR ELECTRICITY SUPPLY OF STEEL AND MINING SECTOR FIRMS

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KEYWORDS

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ABSTRACT

The steel industry's production process is electro-intensive. So, electricity has a significant participation in the cost structure of firms in the industry. An adequate energy portfolio management constitutes an important strategy to ensure the competitiveness of steel. In short, the sector's firms need to have assurance of supply of electricity at the lowest cost possible.

Energy-intensive industries need to take decisions relating to investment in productive capacity of electric power, and which sources should be prioritized, and the establishment of energy contracts and the profile of these contracts. These choices must be guided in the core objective of ensuring the supply at the lowest possible cost. However, an environmentally sustainable production presents itself as a competitive edge.

In this sense, the aim of this study is to analyze the performance of three major groups - Gerdau, Usiminas and Vale - on energy strategies, in Brazil and abroad.

INTRODUCTION

The steel industry's production process is electro-intensive. So, electricity has a significant participation in the cost structure of firms in the industry. A adequate energy portfolio management constitutes an important strategy to ensure the competitiveness of steel. In short, the sector's firms need to have assurance of supply of electricity at the lowest cost possible.

In Brazil, the electricity sector has very favorable competitive conditions in comparison to the rest of the world due to the high degree of diversification of its energy sources. However, the uncertainties of supply, a trend of rising costs and price volatility are creating a troubling and unstable scenario for energy intensive industries.

Energy-intensive industries need to take decisions relating to investment in productive capacity of electric power, and which sources should be prioritized, and the establishment of energy contracts and the profile of

these contracts. These choices must be guided in the core objective of ensuring the supply at the lowest possible cost. However, an environmentally sustainable production presents itself as a competitive edge. Additionally, the discount of at least 50% tariff that consumers engaged in the Free Market Environment (FTA) with renewable energy are given by law provides a potential financial benefit. Thus, it is a strategy consistent prioritization of renewable power generation, provided there is no impact on cost structure. This option becomes even more plausible when considering the potential of renewable energy to be exploited in Brazil.

In this sense, the aim of this study is to analyze the performance of three major groups - Gerdau, Usiminas and Vale - on energy strategies, in Brazil and abroad.

Since the 90s, when the process of reforming the electricity sector had begun, energy-intensive production activities began to develop increasingly sophisticated strategies to mitigate the risk of shortages, price volatility and market liquidity. The three firms analyzed in this paper present strategies in this direction, with an extensive list of investment in generation projects and broad portfolio diversification.

GERDAU

I.1 - Performance in Brazil

Steel production is a process that requires a lot of electricity, mainly in power plants arc, representing a high cost in the steel production process. In 2009, the total cost of energy for the Gerdau Group was approximately 17% including, in addition to electricity, spending on coal, oxygen, natural gas and fuel oil.

Investments in power generation of the Gerdau Group are giving priority to greater use of renewable resources and use of alternative sources in order to reduce costs and thus, so increase the competitiveness of a company that operates in an industry where competition is fierce. Within this energy policy strategy of the Gerdau group, specifically in the fields of hydroelectricity, there are the following:

i) Construction of two hydroelectric power plants: the Coconut Bar and Caçu, in Goiás state with total installed capacity of 155 MW. The hydroelectric plant the Coconut Bar, located on the river course (GO), will have 90 MW and is already in operation. The UHE Caçu, located in the same river, will have 65 MW of power and is still under final construction. Both projects, which required investments of SR 632 million, will make available its entire generation for the production units of the Gerdau Group located in southeastern Brazil.

ii) In February 2008, the National Energy Agency (ANEEL) transferred to Gerdau a concession to operate the hydroelectric complex of St. John - Cachoeirinha, composed of two hydroelectric plants to be built in Rio Cowbird in the cities of Cleveland and Honorius Serpa, in Paraná state. The complex will have an installed capacity of 105 MW (John - 60 MW and Cachoeirinha - 45 MW). The estimated investment is around \$ 300 million. The start of construction is dependent on environmental permits.

iii) Currently, the Group participates in the controlling stake in UHE Dona Francisca Acute located in Rio Grande do Sul with a nominal capacity of 125 MW. The DFESA is part of a consortium (the Consortium Dona Francisca), which holds 95% stake, with the state-owned State Electricity Company (CEEE) holding the remaining 5%. DFESA are shareholders of Gerdau (51.8%), COPEL SA (23.0%), Celesc (23.0%) and Desenvix (2.2%).

However, the supply of electric energy production units of the Gerdau Group is accomplished primarily through a portfolio of long-term contracts with electricity suppliers and is not dependent on a single contract. Doctors use two types of contracts:

i) The contracts concluded in the Regulated Environment (ACR), where Gerdau figure as "Consuming Captive", signed with the distributors to supply the following production units of the Group: Riograndense Piratini Specialty Steel, Guaira, Usiba, Açonorte and Sorocaba. In such contracts the prices are set and established by the National Agency (ANEEL).

ii) The contracts concluded in the Free Market Environment (ACL), where Gerdau figure as "free consumers". This type of contract is used for the following production units of the Group: Araçariçuama, Cosigua, Ceará, Ouro Branco, Divinópolis, Baron Cocalis, Pindamonhangaba and Mogi das Cruzes. These units have power purchase contracts entered into directly with the companies that generate and / or marketers of electricity, with prices set and adjusted according to conditions predetermined by the parties. The transmission and distribution rates are regulated and reviewed annually by ANEEL.

The production unit Açominas, located in Ouro Branco, is the largest integrated facility (the iron ore to steel) Group in the world, uses high levels of reuse (CHP) energy. The company uses waste gases generated in the blast furnace, steel works and coke, allowing cogeneration of over 70% of the electricity needs of the plant. In 2008, the total volume of gas generated, 97.6% were reused for power generation. This technique makes possible that this unit has a significantly lower exposure to market prices for power plants that mini-mills in the Group.

I. 2 - Performance Abroad

In countries where the Group has production units are taken as different strategies will be discussed below.

In North America there are two types of electric power market: regulated and unregulated. In the regulated market, contracts are established with local electric power utilities with tariffs set by region. In the unregulated market price of electricity is set at auction and set their values every 5 minutes. This is a spot market that seeks thus reflect the actual cost of generating electricity. Although the deregulation of wholesale electricity market could create opportunities for more significant reduction of cost and less volatile due to competition from the spot market, prices have recently become much more volatile. Given the weight of this input in the cost structure of the Gerdau Group adopts a conservative strategy of hiring more energy focused on the regulated market. Thus, seeks to reduce volatility and more effective to be able to stabilize this type of cost.

In Chile and Colombia, the electricity is purchased through long term contracts. In Colombia, the electricity contracts were renewed in 2009. In Chile, Gerdau AZA has renegotiated his contract for electricity in 2008. So now all the contracts were extended until the end of 2011.

In Argentina in 2008, Gerdau Sipar signed a contract with Petrobras to supply the energy needs of the new plant from May 2010. However, in view of the postponement of this project, this contract was reviewed.

In Peru, the electricity is purchased through long term contracts, we have all been renovated. A new contract for the purchase of electricity in the Dominican Republic was signed in 2009, for a period of 5 years. In Mexico, the regional power plant, Luz y Fuerza del Ciento, was settled by the government and its operations were taken over by the state company Compania Federal de Electricidad (CFE), with no impact on supply. Because of this, new energy contracts are still under negotiation.

More generally the Gerdau Group realizes that in case of loss / failure of power supply, there is, in the short term, alternative supply in most manufacturing plants located abroad due to the large volume and tension required for operation these productive units.

In these cases (as occurred in Brazil in 2001 when the federal government has set targets for reduction of consumption), the measures and their consequences are discussed with their utilities, while the operational capability is maintained as an emergency to preserve the equipment.

The experience of 2001 in Brazil, the possibility of rationing, decisions and procedures will be determined by the regulatory agency of the Brazilian government. These decisions and procedures may have a materially adverse impact on the outcome of the Gerdau Group, leading to reduced production due to unavailability of electricity and adjustments in the delivery schedule. Although such problems are not common in Brazil, some small units of Gerdau may decide to adopt the use of generators as an alternative to compensate for the shortage or lack of energy.

During the period of energy rationing in 2001, Gerdau has overcome the crisis by redistributing its production among its various industrial units and rationalizing the use of electricity. These measures resulted in gains in efficiency and productivity, which, since when the period of rationing, were incorporated into production processes.

From this experience can be defined strategies in similar situations as you are checking in Venezuela. The government imposed a rationing began in December 2009 with a commitment to reduce by 20% compared to the monthly consumption recorded in 2009. The production unit of Gerdau is working to reduce consumption and increase efficiency to reduce the impact of these constraints on production.

USIMINAS

The main goal of Usiminas in the coming years is the increase in domestic electricity self-generation. Based on this strategy, the company intends to reduce the employment of electricity in the market by taking steps to improve its energy matrix.

In the Ipatinga plant investments were made in the order of R \$ 255 million to build a thermoelectric plant bringing the ability to self-production of 58 MW to 120 MW, representing an increase of 26% to 53% of all electricity consumed in the plant. He was a co-generation project that also started to provide 115 tons / hour of steam for use in industrial process.

Usiminas has installed the production unit of Cubatao a turbine on top of Blast Furnace 2 increasing the supply of electricity by about 12 MW, a level which represents 6% of energy consumption of the plant. In the project, replacing the turbine valves and began transforming the pressure energy of the gas into electricity, no impacts to the environment.

Usiminas has a project to build a new plant, located in Santana do Paraíso, 7 km from the Ipatinga plant. The power plant project includes the construction of a thermoelectric plant of 250 MW with investments of U.S. \$ 400 million. The power plant will total energy independence for both the new unit of Santana do

Paraíso as for Ipatinga. The start-up is scheduled for the first six months of 2011.

In 2009, the Company reduced by 33% its energy consumption compared to 2008 (159 million gigajoules (GJ) to 119 million GJ), and managed to cut a quarter of the consumption of coal, which directly implies lower emissions of greenhouse gases.

A portion of this reduction is due to the rationalization of energy use. With the search for improvements in conservation and efficiency in the past, Usiminas has achieved savings of 580 000 GJ, with just the measures of 2009, the economy had reached 756 000 GJ, totaling over 1.3 million GJ saved.

Usiminas also has diversified its energy sources to gradually replace non-renewable sources for lower environmental impact, like natural gas, and renewable energy. Spending on Materials, Energy, Outsourced Services and Other amounted to little more than \$ 1 billion in 2009. The total energy consumption directly reached 118 million GJ.

In October 2003, the Usiminas System signed a contract with Cemig, as a consumer, free, to supply electricity to their units in Jaipur and Cubatao (1 January 2005 to 31 December 2009) totaling 353 MW. The adjustment index of this contract was the IGP-M accumulated every 12 months. In June 2007 extended its contract was to supply electricity for over 5 years (1 January 2010 to December 31, 2014) for a total of 308.5 MW.

In late 2009, Usiminas began negotiating the contract to review the contract terms and extend the contract term to 10 years (01 January 2010 to December 31, 2019). This new contract is in negotiation with an amount of about 302.00 MW for the initial years. Contracts in effect amount to the amount of \$ 795 million and cover the period from 01/01/2005 to 31/12/2019.

GROUP VALLE

III. 1 - Operations in Brazil

To the group Valle, the management and efficient supply of energy has become a key priority. Its main strategy is to invest in power generation projects to meet the goals of operations to protect against:

- i. The volatility of energy prices;
- ii. The regulatory uncertainties, and
- iii. The risk of electricity shortages.

Accordingly, Valle has hydroelectric plants in Brazil, Canada and Indonesia and is using the electricity produced to meet domestic needs. Energy costs are a major component of cost of production of the company. In 2009 accounted for 15.6% of the total cost of goods sold. U.S. dollars in annual spending power is growing significantly. Were \$ 406 million in 2008, 2009, the cost was \$ 688 million. For 2010 it is estimated that the cost will total \$ 834 million.

Due to the relevance of these costs and growth trend, Vale using the full potential of small hydropower (SHP) where production is entirely directed for its

consumption in the "Southeast System." The production units located in "North System" are 100% supplied by regional energy companies as a free customer.

Because of the uncertainties associated with changes in regulatory structure, risk of increased electricity prices and energy shortages (such as Brazil faced in 2001), management and efficient supply of energy in Brazil have a strategic character for Vale. The company currently owns seven hydroelectric power plants in operation. In 2009, production of electrical energy was 12,509 GWh worth the equivalent of 1,428 MW average, being directed to supply part of the consumption needs of the productive units of the Vale.

In the context of the strategy to mitigate supply risk and cost of electricity, Vale is investing in the construction of a hydroelectric plant located on the Tocantins River in the location of the Strait, on the border between the states of Maranhão and Tocantins. The plant will have a capacity of 1,087 MW. And the Vale will have a 30% stake in the consortium that was established to operate the plant.

III. 2 - Performance Abroad

Internationally in 2009 hydropower plants in Sudbury, Canada produced about 31% of the demand for electricity needed to power industrial operations. These plants consist of five separate generation stations with generating capacity of approximately 56 MW. The generation plant is limited by water availability, as well as restrictions imposed by a water management plan imposed by the provincial government.

In 2009, the diesel generators provide 100% of the electricity needs of the operations of the production units of the Vale of Voisey Bay, Canada. There are six diesel generators on site, of which only four are in operation, producing about 12 MW.

As the cost of energy is a significant component in nickel production for the processing of laterite ores PTI's operations in Indonesia, the strategy adopted is to meet virtually any demand of the electric furnace of PTI at low cost by its two hydroelectric power plants Larona River:

(I) Larona plant, which generates an average of 180 MW and

(Ii) Balambano plant, which generates an average of 110 MW.

PTI has 24 thermal plants include Caterpillar diesel generators, each with a capacity of 1 MW, five diesel generators and generator Mirless Black oil with a steam turbine. These generators are capable of producing 80 MW of power.

Aiming to expand production to 90,000 metric tons of nickel, the Vale is building a third hydroelectric power plant in Sulawesi, Indonesia. The goal is to reduce production costs to meet the expansion. The start-up is planned for the second half of 2011.

The electricity used in the plant of ferroalloys from Dunkirk, France, and in Mo I Rana, Norway, is provided by long term contracts with local suppliers.

CONCLUSIONS AND FURTHER RESEARCH

Since the 90s, when we started the process of reforming the electricity sector, energy-intensive production activities, where stands the steel industry and mining, began to develop increasingly sophisticated strategies to mitigate the risk of shortages, volatility prices and market liquidity. The three groups analyzed in this report fairly present strategies in this direction, with an extensive list of investment in generation projects and broad portfolio diversification.

The analysis of these groups identified that at this conjuncture the major energy consumers adopt a strategy based on two movements:

(I) formation of portfolios consisting of contracts to supply electric power medium and long term in the free market, and

(Ii) invest in building power plants that generate electric power project-based co-generation thermoelectric and hydroelectric power as self-producers.

Prospects and scenarios for the steel industry and mining in Brazil for the rest of the world are very promising and are settled in two scenarios consistent enough. On the one hand, consolidation of a new cycle of economic growth and development of the country. On the other by the growth of world economy "pulled" by the Asian countries, especially China.

Thus, scale and plan for the supply of electric energy is strategic for the industry given the importance that this input has on the cost structure. The provision, cost and volatility of electricity prices can determine losses or gains in competitiveness in a sector that has big global players that work very aggressively.

As a result, the strategy of the double movement of (i) formation of a contract portfolio, and (ii) vertical production indicates an energy policy to be consistent with mitigating risk. Importantly, the Brazilian electricity sector provides the conditions for such a strategy is adopted to efficiently and with emphasis on renewable energy, in line with the low carbon economy, due to the potential renewable sources available for exploitation competitive basis. It is a reality for large groups self-producing developing strategies sophisticated portfolios of renewable electricity generation, which shows the degree of self development that the segment has reached this area.

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THE ROLE OF ENERGY PLANNING IN NEW HYDROPOWER INVESTMENTS

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ABSTRACT

A sustainable economic development program requires an energy system capable of meeting demand efficiently, while minimizing environmental impact. Countries that follow this path must integrate their energy systems with social and environmental concerns. The challenge is to combine development and sustainability, keeping in mind that social and economic development are associated with higher levels of energy consumption and increasing demand for natural resources.

Considering the importance of hydroelectricity to sustainable development, this study maps the main obstacles to increasing the hydropower share of electricity generation that exist even in countries with huge remaining potential. These examples underline the idea that promoting sustained economic development requires government planning and coordination of the energy sector.

INTRODUCTION

A sustainable economic development program requires an energy system capable of meeting demand efficiently, while minimizing environmental impact. Countries that follow this path must integrate their energy systems with social and environmental concerns. The challenge is to combine development and sustainability, keeping in mind that social and economic development are associated with higher levels of energy consumption and increasing demand for natural resources. The challenge is even greater for developing countries, where economic development potentially increases energy intensity, as they move from low energy consumption patterns to higher levels of per capita energy demand.

To mitigate development-related environmental impacts, expansion of energy supply should prioritize renewable sources. Hydroelectricity, for instance, because of its technological maturity and competitive costs, already plays an important role in electricity generation in many countries. However, building new hydro-power plants is quite different from expanding thermoelectric supply,

since the latter can be more market driven, while the former requires central planning, usually implemented by public institutions. In a scenario where there is little government investment in the energy sector, private investment tends to opt for thermo-power projects, which require less capital and shorter investment amortization periods. Thermal power projects also involve lower risks and align better with entrepreneurs' capital opportunity costs.

Considering the importance of hydroelectricity to sustainable development, this study maps the main obstacles to increasing the hydropower share of electricity generation that exist even in countries with huge remaining potential. The paper thus starts with two sections setting out key ideas on energy, environment and sustainable development, and addressing the role of renewable energy in this context. The third section describes features specific to hydropower projects, namely their environmental, political and economic aspects. The fourth section examines the cases of Peru and Honduras, where expansion of hydroelectricity is hampered by deregulated power sectors and a lack of central planning. These examples underline the idea that promoting sustained economic development requires government planning and coordination of the energy sector. Finally, the last section concludes.

ENERGY, ENVIRONMENT AND ECONOMIC DEVELOPMENT: THE IMPORTANCE OF SUSTAINABILITY

GOLDEMBERG & LUCON (2007) regard the biosphere as subject to a continuous process of change from natural causes over which mankind has no control. Large-scale natural change occurs slowly, though, enabling life on Earth to adapt to new conditions. Nonetheless, since the start of the Industrial Revolution in the mid-18th century, man-made environmental impacts and modifications have appeared gradually as population increases and socioeconomic development have caused the pace of natural resource extraction and waste discharge into the environment to accelerate exponentially.

Of all human activities, energy production and consumption have been the origin of most adverse

environmental impacts over the past 250 years, particularly because socioeconomic development has been based on fossil fuel combustion. There is thus a need to mitigate energy sector impacts on the environment, because they tend to reduce quality of life, increase natural resource extraction, unbalance ecosystems and the biosphere, and ultimately bring into question the very future of human life on Earth.

Now, since the mid-18th century, the energy sector's intense use of natural resources and the related environmental impacts have served essentially to meet the energy demands of what today are termed the developed countries, in the process enabling only one third of the world's population to attain a reasonable quality of life. Accordingly, there is considerable potential energy demand from the developing countries, because the 21st century has inherited standards of economic development that entail high levels of energy resource consumption.

GOLDEMBERG et al. (1988) emphasize that it is crucial to eradicate poverty. They argue that this eradication demands that developing countries boost their agricultural productivity and food distribution, implement appropriate sewerage and water distribution networks, permit access to basic education and health services, besides affording basic amenities and developing their industrial and service sectors. All these activities require significant energy consumption. Based on these parameters, there is a clear, unequivocal relationship between socioeconomic development and rising levels of energy consumption.

According to JOHANSSON & GOLDEMBERG (2002), access to efficient, modern forms of energy is one important indicator of a population's conditions of life. They assert that approximately 2 billion people still have no access to electric power nor to modern fuels, such as liquefied petroleum gas. These populations use firewood and agricultural and animal waste to cook and produce heat in processes that are energy-inefficient and sometimes harmful to health. It is thus evident that improving the conditions of life of this population contingent depends on access to efficient, modern forms of energy. Table 1 shows comparative world estimates of per capita energy and electricity consumption in 2008.

Table 1: World per capita Energy and Electricity Consumption (2008)

	Per-capita Energy Consumption (TEP)	Per-capita Electricity Consumption (kWh)
World	1.83	2782
OECD	4.56	8486
Latin America	1.24	1956
Africa	0.67	571

Source: IEA (2010).

Developing countries need to develop socioeconomically in order to improve their conditions of life and reduce the number of people living in extreme poverty. That need, however, will have to be achieved within environmental limits at the same time meeting repressed demand so as not to cause adverse externalities for future generations.

Those prior conditions give the basis for constructing the concept of sustainable development, i.e., which meets present social demands without prejudicing the quality of life of future generations.

As signaled by BÜRGENMEIER (2005), the endeavor to promote sustainable development should be pursued as described in the Brundtland Report (1987), i.e., by exploiting resources, directing investment and adopting techniques and institutional arrangements that make it possible to meet humankind's present needs and those of future generations.

Making sustainable development feasible depends, among other things, on the adoption of sustainable solutions for the energy system, taking into account its interface with the social and environmental spheres. The next section examines strategic policies that make for sustainability in the energy sector.

RENEWABLES AND THEIR ROLE IN ENERGY SECTOR SUSTAINABILITY

Before analyzing and discussing energy strategies, it is as well to discuss overall development strategy as such. On the assumption that there is an unequivocal relationship between socioeconomic development and higher levels of energy consumption, a balance has to be sought in this dynamic relationship, which entails selecting priority sectors of the economy through which achieve economic growth and improve conditions of life for society.

According to PINTO et al. (2007), energy consumption is determined by the interplay of the level of economic activity, the sectorial composition of the economy, and the energy intensity of the economy. In that light, energy consumption changes as a function of variations in one or more of these three vectors. Energy demand projections based on econometric relations between energy consumption and income level ignores variations

on those structural effects, like economy and technology-related changes that entail variations in energy intensity. The former type of analysis is valid for short-term projections, but becomes less reliable as the analytical time horizon is extended, because the hypothesis that structure and intensity effects have significant impact on variation in energy demand becomes far more plausible in longer timeframes.

The relationship between economic development and energy demand is thus not static over time and one of the factors that can alter this relationship is precisely economic structure. In this regard, before any discussion inherent to the energy sector, it is well to consider that an industrial policy focused on sectors that are less intensive in energy consumption, but which produce goods with more added value, can reduce the magnitude of the challenge facing the energy sector.

A country's development process tends to go through an initial industrialization phase with strong investments in heavy industry (see GOLDEMBERG & LUCON (2007)). Then it is possible for development of industries with greater added value to occur, culminating in a process of relative de-industrialization where the service sector gains in importance. This, by and large, has been the development path followed by what are referred to today as the developed countries. In energy terms, this trajectory means increasing energy intensity in the initial stages of development until the point where energy intensity stabilizes and, from then on, begins to decline as greater added-value sectors come to account for an increasing share of the economy, population stabilizes, higher levels of *per capita* income boost residential electricity consumption, and so on.

What is proposed is that developing countries do not need to replicate the development path of the developed countries. It is possible to adopt development strategies focused on sectors that offer greater added value and are less energy-intensive. This kind of strategy approach is referred to in the literature as "leapfrogging", by which it is possible to raise per capita income with less increase in energy intensity.

However, while leapfrogging strategies are a sound economic development approach in some countries, this path cannot be applied to developing countries as a whole, because it rests on a new international organization of work. This is explained as follows: priority for greater value-added sectors does not eliminate the demand for more energy-intensive primary goods, which would have to be met by a set of countries to which the basic industries would ultimately be transferred. It is largely this transfer and the resulting new international organization of work that has enabled developed countries to reduce, to some extent, the energy intensity of their economies.

As regards energy systems, JOHANSSON & GOLDEMBERG (2002) explain that the necessary physical resources and technological capability for the energy sector to take a path compatible with promoting

sustainable development do exist. However, incentive policies must be enacted if these alternative paths are to be taken more widely. They state that policies designed to increase energy efficiency and use of energy from renewable sources are fundamental strategies for achieving a sustainable energy system.

Promotion of energy efficiency is the only available tool capable of meeting the three – conflicting – strategic goals of sound energy policy:

- i. Secure supply;
- ii. Competitive costs; and
- iii. Environmental sustainability.

It should be stressed that even in developing countries there is room to promote energy efficiency through technical solutions that enable demand for energy services to be met using smaller amounts of inputs. JOHANSSON & GOLDEMBERG (2002) also underline the care that must be taken with average consumption values in developing countries, because the degree of inequality in these countries is such that, even when average values are low, there is an elite whose energy consumption is at the same level as in developed countries, thus leaving ample room for the introduction of energy efficiency policies.

However, although energy efficiency policies should be enacted in developing countries, the repressed demand in these countries is of such an order that substantial investment will inevitably be necessary to expand energy supply. The issue raised here is which sources should be prioritized with a view to that expansion occurring on a sustainable basis. For that purpose, it is necessary to format policies to foster increased participation by renewable energy sources, which today account for only 12% of world energy supply.

In the electricity sector, there are some alternative renewable energy sources (hydroelectricity, bioelectricity, wind power, solar power) to be used in expanding the electric power matrix. The major obstacle to most of these sources continues to be their higher cost in comparison to conventional sources. Accordingly, policies are necessary for financing the development of these sources. Among the renewable sources for electric power generation, hydroelectricity stands out for its technological maturity and competitive costs. In addition, there is vast hydroelectric potential to be developed, particularly in developing countries. Nonetheless, in many cases the expansion of electricity supply in such countries is not prioritizing the exploitation of hydroelectric potential. The authors are of the opinion that, among the main reasons are the very particular economics of major hydroelectric projects and the need for greater participation by central State planning, as discussed in the following sections of this article.

HYDROELECTRICITY

Use of hydroelectricity offers substantial advantages in terms of the energy system's quality and its alignment with sustainable development:

- i. Contributes to improving the terms of the energy balance of trade and attenuates exposure to international oil product prices;
- ii. Is the energy source with the lowest average cost;
- iii. Represents one of the cleanest sources in terms of greenhouse gas emissions; and
- iv. Because it demands major capital investment and large-scale generation of direct and indirect employment, it is responsible for more substantial multiplier effects in the economy than other energy sources.

In addition, in terms of electric system operation, availability of hydropower permits technologies with less operational flexibility to be used more efficiently, contributing still further to reducing fossil fuel combustion.

Choosing the most appropriate energy mix involves variables such as: environmental conditions and availability of energy resources, economic environment, technical capacity-building, the degree of development of the electromechanical industries, competitiveness of available energy sources, and so on.

Countries are strongly differentiated by the share of hydroelectricity in their energy systems, given differences in river systems and hydroelectric potential. Allocation of investment to hydroelectric projects is also influenced by environmental concerns, the institutional regulatory environment and public interests surrounding the energy sector. In addition, issues of investment maturity and financing also bear – differently among countries – on the decisions of private and state investors in this energy source.

As regards the environment, it can be said that 30 years ago it was common for the construction of dams and reservoirs to displace large contingents of population. At present, there is strong local opposition to large-scale projects, representing delays in the construction of dams. These impacts caused by big dams are extremely important, but improper environmental evaluations and a lack of sensitivity towards populations affected by major projects are signs of shortsighted energy planning and regulation. These errors have occurred along with the expansion of fossil fuel-fired thermoelectric plants, which raise energy costs and environmental impact via greenhouse gas emissions. As mentioned earlier, the energy system plays a strategic role in a country's economic development, and significant changes in the cost of energy have knock-on effects on various sectors of the economy.

Besides the cost issue, an integrated conception of the energy matrix rests on the understanding that continuous

development of hydroelectric potential corresponds to a reduction in the greenhouse gas emissions caused by thermoelectric plants. As an example of how controversial the issue is, in the late 1980s the Austrian government held a plebiscite to consult its citizens on building a hydroelectric facility on the Danube River. Knowing that the alternative would be to build thermoelectric plants, 70% of the population voted for the hydroelectric plant. Even with these issues in view, many countries where coal accounts for a large part of the electric power matrix have under-exploited hydroelectric potential.

The economic rationale inherent to a major hydroelectric project also influences large in investment decision-making. Large hydroelectric projects are favored by gains of scale, which reduce the cost per kW installed. Table 2 shows cost estimates that illustrate the competitiveness of hydroelectricity against other energy sources and the estimated investment cost for a large-scale project. Even with gains of scale, the necessary volume of funding is very large, estimated at R\$ 12.5 billion for a 5-GW hydroelectric plant.

Table 2: Cost estimates (2009)

Energy Source	Investment (Million R\$/MW)	Load factor	Minimum power cost (R\$/MWh)
Hydro – Large	2.5	70%	95
Thermal – Biomass	2.5	66%	100
Hydro – Medium	3.5	50%	135
Thermal – Coal	3.5	90%	140
Hydro – Small	4.0	55%	140
CCGT	2.0	90%	147
Wind Power	5.0	36%	200
Thermal – Diesel	2.5	90%	>350

Source: SANTOS (2009).

Construction timeframes are rather long and require that investors have the financial capacity to make major capital outlays without receiving operating revenues during the construction period. This long lag between initial investment and cash inflows, added to the large volumes of capital and the long investment maturities involved¹, may discourage private investors who do not

¹ Hydroelectric projects plan to a 30 to 50-year time horizon, which is the time necessary to ensure project viability. In practice, these assets can last 100 years or more (STERNBERG, 2009).

necessarily evaluate the opportunity costs of capital in the same ways as governments.

As a result, government institutions around the world usually feature as the key players in the implementation of large-scale hydroelectric projects, following the example of what occurs in other infrastructure sectors where return on investment is subject to very long timescales. As signaled by STERNBERG (2009, p. 8), “hydropower is among this group of monumental investments that the private sector likes to build and use, but not invest in”. To assure such investments is part of the State’s larger strategy for ensuring social well-fare and safeguarding national interests.

The issues raised here explain the slow pace at which hydro potential is harnessed in most regions of the world (as shown in Table 3), which has been aggravated by the neoliberal reforms begun in the 1980s and 90s that led to a reduction in State participation in the electric power sector, especially in directly inducing investments and planning.

Table 3: Hydropower installed, percent change, potential (1950-2000)

	1950 installed (MW)	2000 installed (MW)	% change 1950-2000	% hydro 2000	Potential, 2000 (MW)	% built 2000
Africa	485	22,122	4461	22	158,400	14
Asia	7584	190,953	2418	19	1,606,000	12
Europe	27,355	241,317	782	23	1,450,000	17
North America	53,569	178,957	234	18	1,290,900	14
America	944	13,281	1307	24	120,000	11
Oceania	2164	109,370	4954	67	866,900	13
World	92,105	756,000	721	22.4	5,492,000	14

Source: STERNBERG (2008, p. 10).

Hydroelectricity is extremely important to the sustainability of the energy system. As suggested by STERNBERG (2008, 2009), this resource must be seen not as a definitive energy solution, but as an “energy bridge” capable of paving the way to a “decarbonizing” energy transition.

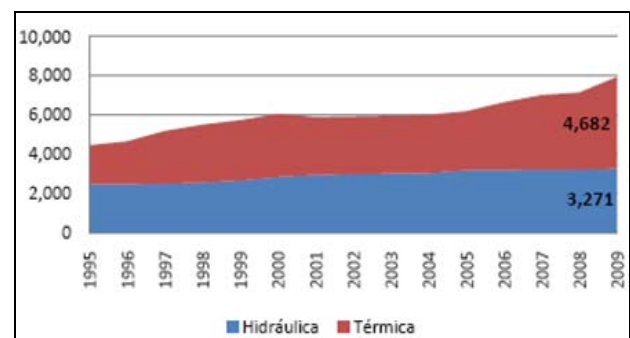
CASE STUDY: PERU AND HONDURAS

The previous section analyzed the economic, political, environmental and social issues relating to under-utilization of hydroelectric potential in many countries. In Latin America, from the 1990s onwards, electric sector deregulation played down the importance of sectorial planning and attributed responsibility for expanding energy supply to market forces, leading to a drastic reduction in investments in hydroelectric projects.

In this regard, note that many Latin American countries expanded their respective electric power generation installations on the basis of thermoelectric facilities, even when holding substantial hydroelectric potential suitable for exploitation. To exemplify these arguments, this section examines the electricity mix of Peru and Honduras. These countries were chosen basically because they are investing massively in thermoelectric

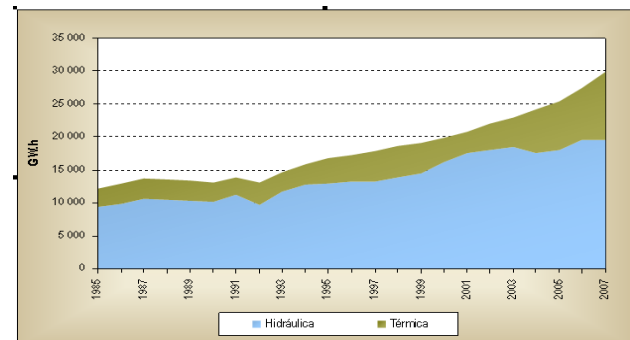
plants to the detriment of harnessing their respective hydro potentials.

According to OLADE (2009), Peru has hydroelectric potential of 62,000 MW, of which it uses only 3,242 MW. Electricity supply could thus clearly be based on that sustainable source. However, recent analysis of the evolution of Peru’s electric power matrix indicates increasing thermopower generation associated with the coming on line of gas from the Camisea reserve. In 2009, thermopower plants totaled installed capacity of 4,682 MW and, although generation continued to be mainly hydro-based, thermoelectric plants now account for 45% of power generation in Peru. Figures 1 and 2 illustrate these assertions.



Source: MINEM (2010).

Figure 1: Installed Power in Peru’s Electricity System MW (1995-2009)



Source: MINEM (2009).

Figure 2: Electricity Consumption in Peru GWh (1995-2007)

The predominance of thermoelectric projects in the expansion of power supply in Peru contrasts with the considerable remaining hydroelectricity potential in the country. This apparent paradox can be understood by briefly examining deregulation of the Peruvian electricity sector in the 1990s.

As in many countries (Brazil among them), neoliberal-based reform of the Peruvian electricity sector was intended to promote competition in the generation and

commercialization segments, and that competition was to be made workable by guaranteed access to the transmission and distribution segments of the chain, which were characterized as natural monopolies. In that regard, the main purpose of the reform was to promote sector efficiency by stimulating competition, while at the same time attracting the capital necessary for the sector to expand.

However, the logic of private enterprise prevailed and priority was given to investments in thermoelectric projects to the detriment of expanding hydroelectric capacity. That choice rested on the fact that thermopower projects demand smaller capital investments and offer shorter maturities, as explained in the previous section, as well on funding and institutional framework concerns.

This larger share by thermal plants tends to increase the marginal cost of operating the electric system. These higher operating costs are not reflected in higher tariffs, however, because natural gas prices are heavily subsidized. Added to this is the fact that exploration of the Camisea reserves is reducing the need to import oil products, which are subject to price volatility and cause impacts on the balance of payments. The question that arises is: Why not reduce dependence on oil by making greater use of renewable energy sources?

Meanwhile, analysis of Honduras's electricity sector indicates that there the option to invest in thermopower plants to the detriment of hydro projects can be taken independently of electricity sector deregulation and can occur in vertically integrated monopolies where there is no effective planning, and system expansion is left to the responsibility of private players.

In Honduras the electricity sector is characterized by a

strong State presence in planning, operation and asset ownership. The State nature of this system rests on the vertically-integrated monopoly model. Note that the liberal reform prepared in the mid-1990s was ultimately not entirely implemented. Accordingly, the electricity sector continued to be coordinated and operated by the Honduran State electricity enterprise. However, regarding generation facilities, private investments grew greatly, to majority proportions, leaving the State enterprise with the responsibility of purchasing, i.e., contracting thermal-sourced electric power from foreign private firms.

Until the mid-1990s, electric power supply in Honduras was essentially hydroelectric, and the generating plants were State-owned. Since then, the mechanism for expanding power supply came to be based on investments by private players that generally have been electing thermal plants projects. Table 4 shows the increasing share of thermoelectricity in Honduran generating capacity.

This profile of electric power supply expansion in Honduras is paradoxical in view of its available hydroelectric potential of the order of 2,000 MW. In that respect, it can be seen that, as in Peru, the economic logic of the market has overridden sustainable expansion of electric power supply. Thence the need to resume energy planning, which is fundamental if hydroelectric potential is to be utilized.

CONCLUSIONS

The energy sector is substantially and inseparably connected with the socio-economic and environmental spheres, because development requires rising levels of

Table 4: Generating Capacity in Honduras MW (1967-2009)

Años	Tipo de Central							Variación	
	Plantas Estatales			Plantas Privadas					
	Hidráulica	MDMV	T. Gas	Hidráulica	MDMV	T. Gas	BIOMASA	Total	Anual %
1967	31.0	15.7	----	----	----	----	----	46.79	-0.2
1968	31.6	27.4	----	----	----	----	----	59.05	26.2
1969	31.6	27.7	----	----	----	----	----	59.25	0.3
1970	30.2	30.7	15.0	----	----	----	----	75.89	28.1
1971	70.2	31.3	15.0	----	----	----	----	116.50	53.5
1972	70.2	31.9	28.6	----	----	----	----	130.68	12.2
1973	68.6	21.1	28.6	----	----	----	----	118.30	-9.5
1974	68.6	50.4	28.6	----	----	----	----	147.64	24.8
1975	68.6	48.9	28.6	----	----	----	----	146.12	-1.0
1976	68.7	48.9	28.6	----	----	----	----	146.14	0.0
1977	68.7	51.3	28.6	----	----	----	----	148.55	1.7
1978	108.7	51.8	28.6	----	----	----	----	189.02	27.2
1979	108.8	52.8	28.6	----	----	----	----	190.12	0.6
1980	108.8	84.1	28.6	----	----	----	----	221.47	16.5
1981	108.8	85.6	28.6	----	----	----	----	222.97	0.7
1982	131.3	83.7	28.6	----	----	----	----	243.57	9.2
1983	131.3	83.3	28.6	----	----	----	----	243.14	-0.2
1984	131.3	113.8	28.6	----	----	----	----	273.69	12.6
1985	424.3	103.3	28.6	----	----	----	----	556.20	103.2
1986	424.4	103.3	28.6	----	----	----	----	556.30	0.0
1987	432.4	103.3	28.6	----	----	----	----	564.30	1.4
1988	432.4	103.8	28.6	----	----	----	----	564.80	0.1
1989	432.4	104.8	28.6	----	----	----	----	565.80	0.2
1990	432.4	99.8	15.0	----	----	----	----	547.20	-3.3
1991	432.4	89.4	15.0	----	----	----	----	536.80	-1.9
1992	431.0	88.4	15.0	----	----	----	----	534.40	-0.4
1993	433.5	88.6	15.0	----	----	----	----	537.10	0.5
1994	432.7	92.9	18.0	0.8	20.5	----	----	564.90	5.2
1995	432.7	93.2	76.5	0.8	107.7	39.5	----	750.40	32.8
1996	432.7	92.8	76.5	0.8	84.5	39.5	----	726.80	-3.1
1997	432.7	92.8	76.5	0.8	84.5	39.5	1.5	728.32	0.0
1998	432.7	93.6	63.0	0.8	130.7	39.5	1.5	761.77	4.6
1999	432.7	94.0	63.0	0.8	288.2	39.5	1.5	919.71	20.8
2000	434.4	92.8	63.0	0.8	288.2	39.5	1.5	920.20	0.05
2001	434.4	93.2	63.0	0.8	290.7	39.5	1.5	923.10	0.32
2002	464.4	92.7	33.0	1.3	395.7	39.5	17.0	1,043.62	13.24
2003	464.4	92.7	33.0	2.5	395.7	39.5	17.0	1,044.85	0.12
2004	464.4	91.6	33.0	10.5	609.9	39.5	30.0	1,279.91	22.40
2005	464.4	91.6	33.0	14.7	823.8	39.5	59.8	1,526.80	19.38
2006	464.4	91.6	33.0	38.5	821.2	39.5	59.8	1,548.01	1.39
2007	464.4	91.6	33.0	55.3	816.8	39.5	67.8	1,568.32	1.31
2008	464.4	91.6	33.0	57.5	824.8	39.5	81.8	1,592.58	1.55
2009	464.4	91.6	33.0	57.5	828.4	39.5	91.4	1,605.79	0.83
En las plantas hidráulicas y biomasa privada, es capacidad firme según contrato.									

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energy consumption, while at the same time using resources extracted from nature as inputs, thus causing environmental impacts. In that light, in order to promote sustainable development, expansion of energy supply must occur in line with new paradigms where energy efficiency policies and greater participation by renewable energy sources are essential.

Renewable energy sources, it must be stressed, tend to entail higher costs than conventional generation sources. Accordingly, policies to promote such sources may be necessary at first. Policies of this kind are justified by the environmental benefits deriving from such sources and the prospect that, in the medium term, increasing scales of production and technological maturation will make them more competitive as economies of scale are exploited and learning is brought to bear. However, hydroelectricity stands out among renewable energy sources, because it is more competitive and technologically mature than other renewable and non-renewable sources.

One prime objective of properly formulated energy policy is to guarantee secure supply. That supply, however, must be competitive so as not to prejudice the competitiveness of the economy and the ability of the population to bear the costs. In line with that principle, the liberalizing electricity sector reforms of the 1990s were designed to make the sector more efficient by encouraging competition in the energy generation segment.

However, if system expansion is left to market forces, there is no guarantee that such expansion will occur in the manner most beneficial to society, because in such a situation it is the outlook of private interests that prevails. The examples of Peru and Honduras show clearly how the logic of private capital, which was prioritized by the neoliberal reforms of the 1990s, led to investments only in thermal plants, even though those countries had major hydroelectric potential. There are thus signs of incompatibility between the neoliberal reforms and investments in hydroelectric projects.

Market logic permits investors not to prioritize social or environmental variables in their project assessments. Their focus is strictly financial. As a result, sustainable expansion of the electric power matrix demands an energy policy that lays down basic guidelines for sector expansion. In order to implement such a policy, new regulatory and market instruments must exist to make it possible to implement a planned matrix, particularly a return to State planning and encouragement for the formation of public-private partnerships.

As regards investment in hydroelectric projects, investor risk perceptions must be allayed, and that depends on environmental licensing-related risks being transferred to society, attractive funding conditions and energy purchases being guaranteed by establishing long-term contracts.

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OPTIMIZATION MODELS TO SUPPORT SUSTAINABLE ELECTRICITY PLANNING DECISIONS

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KEYWORDS

Energy decision making, electricity generation

ABSTRACT

Over the last decades, models and concepts related to sustainable electricity planning decisions have been changed according to the society, energy policy objectives and concerns. New and clean energy technologies are emerging as major contributors for the achievement of a set of imposed goals, being the energy efficiency combined with renewable energy sources (RES) a key strategy for a sustainable future. Power planning based on optimization models plays an important role for, not only electricity industry decision making process, but also for all processes where complex decision must be made. Following the idea of sustainability combined with the emergence of RES, this study aims to present an on-going research project that involves the development of a set of mathematical models to be used on the electricity planning. Assuming a time period of 10 years and through scenario analysis, the expected impacts in terms of costs and CO₂ emissions were evaluated. The behaviour of system when coal and gas fuel price varies is observed. The results put evidence the significant wind power and hydro power impacts on the electricity sector performance and demonstrate importance of these technologies to achieve the European Union goals for the sector.

INTRODUCTION

The 20-20-20 targets are an example of how objectives changed envisaging now to combat climate changes and to increase the European Union energy security and competitiveness. These targets also contribute to reach a high energy-efficient and a low carbon economy at the European level. Because of that, new and clean energy technologies are emerging as major contributors for the achievement of these set of goals. Energy efficiency combined with RES is then a key strategy for a sustainable future.

Power planning based on optimization models plays an important role for, not only electricity industry decision making process, but also for all processes

where complex decision must be made. The paradigm of power planning where only economic interests were taken in consideration, is now overcome. The diversity of available technologies to produce electricity along with the social and environmental arguments turn the task of decision makers more difficult turning the planning based on optimization models an essential tool. Moreover, the importance of these models for generation expansion planning is well addressed in literature. To Pereira and Saraiva (2010), generation expansion planning allows to identify the most adequate technology and expansion size taking into account economic criteria, ensuring at same time that the installed capacity follows the expected technical, sustainable and policy concerns. Also Meza et al. (2009), consider that generation expansion planning aims to determine the best solution for future generation utilities taking into consideration that minimum mistake will result in a loss of a large amount of money and that society welfare concerns must be taken into account in the way that demand must be met to avoid social costs. To Tekiner et al. (2009), the main concern of generation expansion planning is to find the least cost expansion plan according to the characteristics of each electricity system.

Although a great importance is given to the economic aspect of generation expansion planning, it is interesting to observe an increase of environmental concerns over the last years. To Li et al. (2010), beside the economical aspect, optimization tool can be extremely useful to solve decision maker's problems where environmental issues are considered. Also Diakoulaki et al. (2005) encompass on their study both the importance of the economic dimension of the energy decisions and the minimization of environmental impacts. Cai et al. (2009) enhance the environmental aspects latent on the electricity decision making. On the authors study, these concerns and others like fossil fuel increasing prices, reliability and security of supply are seen as on-going challenges faced by decision makers around the entire world.

However, nowadays power planning models start to be more complex than in past decades. This is largely due to the diversity and increasing of power RES generation technologies, especially those with variable output. Also, the liberalization trend of electricity

markets and the increasing decentralization of electricity production systems create additional needs to traditional planning models. Given this, the analyses of the effects of RES in traditional electricity power plants operating performance, is frequently addressed or included as an important factor to be considered in generation expansion planning optimization models. Works like Holttinen and Pedersen (2003), Kamalinia and Shahidehpour (2010), Rosen et al. (2007) or Isaac et al. (2010) among many others addressed the impact of large-scale wind power on thermal power system operation, on additional reserve needs and on the importations-exportations balance. These works demonstrate the need to properly take into account these expected impacts of the increasing installed wind power during the formulation of the electricity generation planning models.

Following literature concerns described above, this paper aims to study the impacts that large hydropower plants and wind power plants have on electricity sector, considering fluctuations of coal and gas fuel prices.

The remaining sections of this paper are structured as follows: section 2 presents the dataset and the proposed electricity planning model, section 3 describes and analysis the cost and emissions results of the proposed model and section 4 presents the conclusions.

DATASET AND MODEL

Electricity Sector in Portugal

Considering the growth of human lifestyle that is seen nowadays, an increased in power demand is being expected. Portugal is no exception and according REN 2008 report, until 2019 is expected an increasing of the power demand and peak load at a medium rate of 4,4%. However, a more recent REN report (REN, 2011) shows that from 2009 to 2010, the Portuguese electricity consumption have suffer an increasing of 4,7% from 49873 to 52205 GWh.

Portuguese Decree-Law nº 29/2006 of March 15 established the organization and operation of the Portuguese electricity sector. The electricity production activities may be classified in two different regimes: The ordinary regime production (OPR) and the special regime production (SRP). The special regime corresponds to the production of electricity based on cogeneration and endogenous and renewable energy sources supported mainly by feed in tariffs. On the other hand, the ordinary regime corresponds to the traditional centralized power plants such as the large thermal and hydropower groups. In 2010, with a total production of 32169 GWh, ordinary regime production contributed to about 62% of total production. From ordinary regime almost half of it, 46%, was provided from hydro power and the remaining come from traditional large thermal power plants, 54% (REN, 2011). Special regime production, which encompasses essentially the wind power, is coming to increasing. This can be proven with

the increase of 24% from 2009 to 2010, which comprise a share of 34% of total production in 2010.

It is notorious that Portuguese power generation electricity system comprises mainly a mix of hydrothermal system complemented by an increasing share of wind power. With a total installed power of 7407 MW, thermal power units are still the largest source of electricity generation. This thermal power generation is provided essentially by coal, gas and fuel oil power units, each one with specific operation characteristics. Thermal power units like coal power stations, because of its lower flexibility as well as its lower operation price, tend to be the major source of electricity production operating several times as base load security. On the other hand combined cycle gas turbines despite its higher fuel prices are characterized by its lower emissions and its higher flexibility, and so usually used to cover peak load situations (Fraye, 2001). Despite of this, power production originated from large thermal power plants have been decreasing. A reduction of 27% was seen from 2009 to 2010 where fuel oil and coal were the most affected with a reduction of 88% and 45% respectively, while gas presented only a reduction of 7%. In on one hand this may be explained by the need to mitigate Greenhouse gas (GHG), leading to strong investment in new and clean energy sources and the decommissioning of the oldest and more pollutant units, on the other hand 2010 was a wet year favouring the hydropower production rather the thermal power. The privileged geographical position of Portugal is essential for the new investments in what concerns RES. Hydropower production provided from large dams and run-of-river units is a perfect example of that. With a total installed power of 4578 MW, hydro power production increased 88% comparatively to 2009, contributing to 28% of total consumption in 2010. This significant production increase was related to an high Hydraulic Productivity Index (HPI), about 1.3, that was verified during 2010. This was a rainy year and HPI reached a value unseen since 2003 (REN, 2011). To take advantage of this potential, in 2007 the national dams plan with high hydraulic potential (PNBEPH) was published (INAG, 2007). Among others measures, reinforcement of existing hydropower units as well as the investment in new ones is considered. Until 2020, a total installed power of 7000 MW is expected to be operational. This value corresponds to 70% of Portuguese potential and an increase of approximately 53% from the current values.

Besides the Portuguese geographical characteristics and the mitigation of GHG emissions objective, the large dependency from other countries to as well as the economic boost for the country is seen by the Portuguese government as important reasons to invest in new and clean technologies. In 2007, energy importations reached 82,9% of the total energy consumption and only the production of renewable energy sources contributed to the reduction of external dependency (DGEG website). However, in 2010 the

energy importations reduced by 23% comparatively to 2009. On the other hand, exportations have increase 108%. This can be seen as a reflection of the effort of Portugal to meet European Commission directives and Kyoto protocol in an attempt to mitigate the environmental issues and also due to the fact of 2010 has been a rainy year which contributed to a higher hydropower production.

A necessary increase in the investment on new power sources, especially wind power, is so being noted. Only in 2010, about half of total SRP production was provided from wind power sources which represent an increase of 20% in relation to 2009. This production corresponds to a total installed power of 3702 MW (REN, 2011) that is been increasing during the last years as shown in the plot of Figure 1.

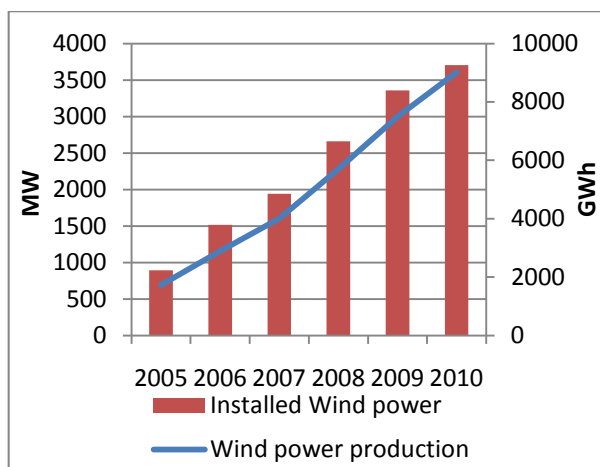


Figure 1: Wind power evolution in Portugal (source: own elaboration from REN data)

However, wind installed power is still far away from the potential offered by Portuguese wind potential. According to Ministry of Economy, Innovation and Development (MEID), until 2020 a total installed power of 8500 MW is expected. This value takes already into account a set of factors such as power demand evolution and technical and economic viability of offshore technology. According to Portuguese government targets for 2020, 60% of total electricity production will come from RES, instead of the 45% projected to 2010.

The evolution of electricity sector in Portugal during the last years, as well as the existing future investments projects, reflects the government policy aiming to reach European Union target on emissions reductions, contributing also to the reduction of external energy dependency and to the growth of Portuguese economy.

Generation Expansion Planning Model

The non-renewable characteristic of fossil fuels and the continuous exploitation of this kind of resources by human kind, together with the policy instability noted worldwide during the past years, caused essentially due to oil interests, are related with the continuous upswing of fuel prices. Besides of that, the increase of

environmental concerns is nowadays in focus. The presented model aims to minimize the total costs and emissions of future power generation units.

(1)

(2)

Equations (1) and (2) presented above are the objective functions of the proposed model, aiming to minimize both values. Equation (1) represents the total costs of generation expansion planning while equation (2) represents the total emissions amount, measured by the CO₂ value. A set of equations referred to model constraints are also used, taking into account, important assumptions on demand requirements, technical characteristics and political concerns. A full description of the model may be found in [Pereira et al., 2011].

The dataset for plants description and demand growth forecast was obtained on the literature, essential from REN (data), and Ferreira (2008)

The model was calculated for a scenario considering coal and gas prices evolution during the forecast period in order to allow the comparison with the same case study of [Pereira et al., 2011] where no evolution on fuel prices was considered. International Energy Agency (IEA, 2010), forecast until 2020 an annual growth rate of 1,33% and -1,21% for gas and coal respectively. According to IEA (2010), the decline seen on coal prices rate is due to the competition between coal supplies that may lead to a significant increase on productivity in coal mining, resulting also in cost reduction. On the other hand IEA also believes that given world hard coal reserves, 729 billion tonnes, very high prices will not last (IEA, 2010).

The next section presents the results and discussion of model solution taking into consideration Portuguese electricity sector characteristics and IEA (2010) perspectives for gas and coal prices evolution.

RESULTS AND DISCUSSION

The plot shown in Figure 2 represents the Pareto curve results for the specific study considering the case of coal and gas variable fuel prices, obtained after all model simulation (R0 to R9). Simulation R0 refers to the optimal cost solution while simulation R9 to optimal emission solution. The other simulations are related with intermediate values of CO₂ between optimal cost and optimal emission solutions. For this particular case of study, Pareto curve represents the trade-off between costs in €/MWh and the CO₂ (t/MWh) originated from power production.

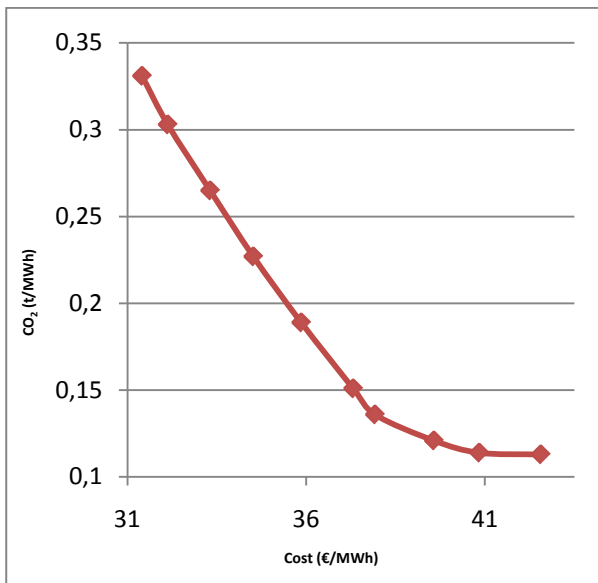


Figure 2: Pareto curve of model

The non-linearity of the system trade-off is visible in the Pareto curve. As the CO₂ get more restrictive values, the cost of operation and investment in power system will be higher. Note that for values up to 37.425 €/MWh the curve slope is much higher which means that the cost is increasing in an acceptable way since the amount of CO₂ reduction is significant. On the other hand, for values higher than 37.425 €/MWh, a substantial increase of cost is observed for an insignificant decrease of CO₂ emissions. Comparing with Pareto curve of (Pereira et al, 2011), where coal and gas fuel prices were assumed as constants, differences in new power plants assigned to each solution, although slightly, were obtained. For the optimal cost solution simulation (R0), lower cost were obtained, for the variable coal and gas price scenario under analysis. If no emissions limits are imposed or any environmental concerns are taken into account, the model converges mainly to the investment in new and less expensive coal power plants. This is even more evident when the coal price is assumed has been decreasing during the analysed period. On the other hand, for the optimal emission solution simulation (R9), higher costs were obtained compared with Pereira et al. (2011). The decommissioning of old coal power plants assumed by model, based on REN (2008), the non-investment in new coal power plants and the investment in CCGT units considered to be less pollutant but more expensive, were the reason for this increase. Besides that, the investment in new and cleaner power units such as wind power plants, characterized by its higher investment costs, contributed to the increasing of costs. Table 1 shows all the results addressed above.

Table 2 at appendix presents the production of all considered power units for the year 2020 for the variable fuel prices scenario. Comparing both scenarios, the increase of coal power units' production when fuel prices were considered variable is evident. This is

essentially because of the negative rate growth of coal price considered for this study. It is also important to refer that coal power unit's production is verified only for solution cases R0 to R3, mainly because of the low emissions targets imposed. Comparing the existent coal and gas power units' production the significant amount of coal unit's production over CCGT units when no emission limits was considered is also noticeable. Besides that, is possible to observe the decrease of coal production and the increasing of CCGT production as more environmental ambitious measures are imposed to the model.

The achievement of environmental targets is only possible with the investment in new clean technologies. However this investment has higher cost. The plot shown in Figure 3 in appendix represents the wind power cost influence when different values of installed power were considered. In the specific R2 simulation case, values of 1300 MW, 1500 MW, 2000 MW, 3600 MW and 4000 MW were imposed to new onshore wind installed power. For the first three cases higher investment cost were obtained due to the need to resource to the much more expensive offshore wind power plants.

In addition to the targets achievement, the investments in renewable technologies also allow to reduce the external energy dependency of the electricity system. From the results, comparing with the results presented in Pereira et al. (2011), small changes were obtained. These results were basically caused by the considerations used on fuel prices and consisted on an increase of coal power production in detriment of gas production. An increase on new coal power units' production was seen and consequently the production of old gas power units has decrease once no new gas power plants were installed. The others power units' production variations were obtained mostly because of modelling considerations.

CONCLUSIONS AND FURTHER RESEARCH

This paper follows the same model addressed in Pereira et al. (2011) for the optimization of electricity planning and in particular for the generation expansion planning. A deterministic programming model is presented aiming to support the long term strategic decision and taking into account the need to reconcile economic and environmental objectives. A case study close to the Portuguese electricity system was addressed, characterised mainly by a mixed hydro-thermal-wind power system where coal and gas fuel prices are assumed as variable during the entire planning period. The results indicate that as the CO₂ objectives become more restrictive, in general the least expensive way to comply with this restriction is the replacement of coal by CCGT and wind power production. On the other hand, considering no CO₂ restrictions coal power units will be the main power sources, with an increase on installed power and a significant increase in the production. Wind power

contribution only increases significantly for highly environmentally constrained solutions. In what concerns hydropower, the influence of this energy source on the RES share is evident and noted for all scenario simulation results

Imposing to the models fixed values of new installed wind power lead to different scenarios that, although not being optimal Pareto solutions, may be interesting from the strategic decision makers' perspective. These solutions ensure the required CO₂ levels at a higher cost but contribute to the reduction of the external energy dependency of the country and the increase of RES share in the electricity balance. For this particular case study, comparing with the one seen in Pereira et al. (2011), slight changes in RES share and consequently energy dependency were noted. However, even with slight changes on results, these were seen principally on gas and coal production and installed power. The increase of coal installed power replacing gas may be easily explained by the coal reduction price and the assumed increase of gas price verified. It is also important to refer that the consideration of a possible increase on coal fuel price was not forgotten and it is seen as a consideration to be taken into account for future work analyses.

The presented models demonstrated that long term planning decisions regarding one generation option should not be taken individually, because this will affect the entire system equilibrium. Future work will address the need to combine long term energy expansion strategies with the results of short terms operations decisions of the system, recognizing the impact that the hydro-wind power combination strategies may have on the efficiency of thermal power plants. For this, new and complementary optimization models will be developed and presented.

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APPENDIX

Table 1 – Comparison of evolution of installed power, cost and CO₂ emissions in year 2020

Installed power in 2020 (MW), base scenario (Pereira et al., 2011)				
	R0		R9	
Coal	4350		-	
Gas	-		6422	
Installed power in 2020, variable coal and gas fuel prices scenario (MW)				
Coal	4650		-	
Gas	-		6441	
	Cost (M€)	CO ₂ (Mton)	cost (€/MWh)	CO ₂ (ton/MWh)
Optimal objective functions solutions, base scenario (Pereira et al., 2011)				
Optimal cost solution (R0)	20526	218	31.095	0.33
Optimal emission solution (R9)	27307	74	41.367	0,113
Optimal objective functions solutions variable coal and gas fuel prices scenario				
Optimal cost solution (R0)	20402	219	30.907	0,331
Optimal emission solution (R9)	27767	74	42.064	0,113

Table 2 – Contribution of electricity generation in 2020, variable Coal and Gas fuel prices scenario

		R0	R1	R2	R3	R4	R5	R6	R7	R8	R9
Contribution of electricity generation (%)	Coal (new)	44,4%	35,5%	13,3%	0%	0%	0%	0%	0%	0%	0%
	Coal (existing)	4,2%	5,2%	5,2%	5,2%	0%	0%	0%	0%	0%	0%
	Gas (new)	0%	0%	23,1%	36,7%	41%	41%	41%	40,1%	40,7%	39,4%
	Gas (existing)	0,3%	3,9%	2,7%	2,4%	3,5%	3,5%	3,5%	2%	0,3%	0%
	Wind (new)	7,5%	7,5%	7,5%	7,5%	7,5%	7,5%	7,5%	11,7%	14,2%	14,5%
	Wind (existing)	11,2%	11,2%	11,2%	11,2%	11,2%	11,2%	11,2%	11,2%	11,2%	11,2%
	Hydro (new)	17,4%	22,4%	18,6%	18,9%	19,9%	21,5%	17,4%	18,5%	18%	21 ⁱ %
	Hydro (existing)	8,7%	8%	12%	11,8%	10,5%	9%	13,1%	10,1%	9,3%	7,7%
	SRP	6,3%	6,3%	6,3%	6,3%	6,3%	6,3%	6,3%	6,3%	6,3%	6,3%
Share of RES (%)		47.9%	52.3%	52.5%	52.5%	52.4%	52.4%	52.4%	54.7%	55.8%	57.5%
Energy dependence (%)		52.1%	47.7%	47.5%	47.5%	47.6%	47.6%	47.6%	45.3%	44.2%	42.5%

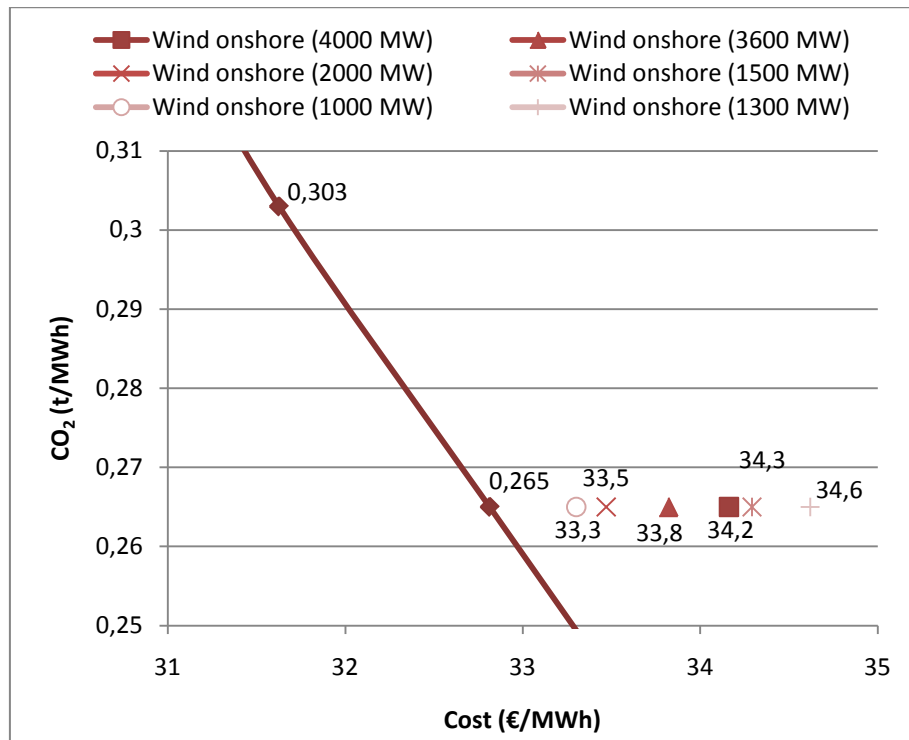


Figure 3 – Wind power price influence

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POLICY AND LEGISLATION FOR A NEW ENERGY PARADIGM: THE CASE OF THE PORTUGUESE LEGAL FRAMEWORK FOR MICROGENERATION

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KEYWORDS

Microgeneration, Feed in Tariff, Regulation

ABSTRACT

Following the European Union energy strategies and recommendations, national governments are encouraging microgeneration related investments. The national government plays an important role on the effective introduction of microgeneration technologies into the markets and daily life of citizens. In the National Plan for Action on Energy Efficiency (NPAEE), the extensive use of microgeneration technologies in a decentralized electricity system is presented as one possible system to meet the future objectives of the Portuguese government for the energy sector. Several incentives were created to promote the adoption of microgeneration technologies through policy measures such as subsidies on the electricity generated by microproducers, investment subsidies and by creating awareness/informing the public about microgeneration.

This paper presents the Portuguese electricity system and the role of policy and legislation for the development of microgeneration in Portugal. The legal framework is analyzed along with the incentives and tax benefits for different microgeneration technologies. The detailed analysis of the Portuguese legal framework is made in order to ascertain the main features that may induce the project success or failure and the role of the defined payment rates namely identifying the possible success factors of these laws and regulations.

INTRODUCTION

Microgeneration projects are assumed to be essential to the decrease of the carbon intensity in the energy sector, contributing to the achievement of the European Union objective of emissions reduction. Energy efficiency and renewable energy (RE) are a priority and strategic sector for Portuguese government, as it has potential to increase competitiveness of the national economy and generate a greater degree of energy security. Over the last years, various measures have been approved to promote, develop and achieve proposed targets of 39 to

45% of electricity produced from RE by 2010 (one of the most ambitious RE goals among the member European Union). Portugal turned to reduce its huge dependence on imported fossil fuels and meet its international commitments to reduce carbon dioxide emissions.

The national directive proposed targets for consumption of electricity produced from renewable energy sources. Portugal assumed the commitment to achieve an ambitious target of 39% of electricity generated from renewable sources, representing the third largest contribution of the EU15. However, with the presentation of the National Energy Strategy approved by Resolution of the Council of Ministers nº 169/2005 of 24 October, the goals were revised once already achieved the target of 39% before the year 2010, rising to new goal to be 45%.

The Government of Portugal has given special attention to microgeneration, which has become popular as a sub-sector in Europe's strong market for renewable energy, allowing any individual access to his or her own system of energy connected to the electricity grid.

Microgeneration technologies applied in small scale energy generation can generate electricity (or heat) from a renewable energy resource (such as micro wind turbine or solar photovoltaic) in low voltage (LV) that can be delivered to the electric grid. Microgeneration technologies is seen as complement to large power plants, reduce investments in transmission and distribution, and have added value to implement in short periods of time, with lower investment risks (Ellern et al., 2003). Small central of microgeneratoin located near or in the local of consumption reduces losses in transmission and distribution grid, in Portugal, the value of the transmission and distribution losses is the 8,35% of the consumption in 2009 (ERSE, 2010).

However, the decentralized power technologies and microgeneration are still too expensive for the consumers (Keirstead, 2007), so economic incentives and government regulations are essential to strengthen the development and provide a profitable future for this new concept of energy. It is essential to create conditions for investment in microgeneration. Feed in tariffs (FITs) are a way to support and subsidize

microgeneration. In general, these remuneration rates ensure the connection to the grid and buying the generated electricity during a period. This stimulus has proved investment in renewable energy technologies with greater success (Gipe, 2006). Empirical evidence on microgeneration investments conditions to success and failure give information that could guide policy-makers with regard to legal and incentives instruments design. Rogge and Hoffmann (2010), for example, studied the impact of the European Emission Trading System, the Union's regulatory instrument for the achievement of EU green-house gas (GHG) emission reduction targets. To analyse this case these authors combined systems of innovation and environmental economics literature.

Furthermore, according to General Directorate for Energy and Geology (DGEG, 2009), residential and services buildings account for about 30% of final energy and more than 60% of all electricity consumed at the national level, that reflects in a greater weight in distribution of primary energy by sector and also a greater share of emissions of GHG. Renewable energy in buildings offers the opportunity to diminish energy dependence, reduce pollutant emissions and create new employment (Ministério da Economia e Inovação, 2007).

These systems when installed in buildings are technically and economically viable, contributing to the achievement of energy efficient buildings. The economic attractiveness of microgeneration systems is still strongly dependent of economic incentives, feed-in tariff, given directly and indirectly from the government (Campoccia et al, 2008). Given the availability of several different technologies or investment opportunities, the evaluation of projects to decide what is the most profitable is fundamental for the private investor. It is also a necessary condition to ensure interest for the progressive deployment of new energy technologies and for sustainable growth of the electricity sector.

This paper presents a framework for the analysis of the economic viability of microgeneration systems connected to grid under different scenarios in the light of current legislation and the previous in Portugal. This study is based on photovoltaic technologies in different places. The assumed legal framework is based on the Regime "Renewables in Time", in conjunction with schemes that assist the microgeneration of electricity. The importance of the tariffs is discussed.

The paper starts by presenting some considerations of microgeneration as well as its framework in the Portuguese Electricity System. Then it presents an economic analysis of a photovoltaic installation. The economic main aspects of the system are presented.

THE PORTUGUESE ELECTRICITY SYSTEM

Portuguese electricity sector was defined by Decree-Law 182/95 to 187/95 and changed by Decree-Laws

56/97 and 198/2000. More recently, Decree-Laws 184/2003 and 185/2003 initiated a revision process of the National Electricity System (NES), addressing the adaptation of the Portuguese system to the new Iberian Electricity Market (MIBEL). The organization of the National Electricity System assumes a model based on the existence of two sub systems, the public electricity system is responsible for ensuring the supply of electricity and the independent electricity system that comprises the non-binding electricity system and Special Remuneration Producer. Figure 1 represents the general structure of the Portuguese Electricity System.

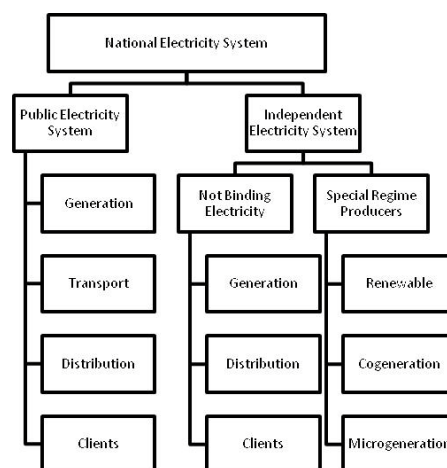


Figure 1 – National Electricity System (Source: Adapted for ERSE and REN)

Thus, economic agents may choose to establish contractual relationships with suppliers under the conditions approved by Energy Services Regulatory Authority or negotiate directly with the traders operating in the market liberalized. According to the legislation, Decree-Law 29/2006, in the National Electricity System, the activities of production and marketing are in free competition and the transport activities and distribution are developed in accordance with the allocation of public service concessions. It is up to Energy Services Regulatory Authority regulate the activities of transport, distribution and sale of electricity, as well the suppliers. In line with this, the electricity industry in Portugal can be divided in four main activities: generation, transmission, distribution and marketing.

Electricity generating includes producing and selling electrical energy using different technologies and primary energy sources (coal, gas, water, wind, biomass, solar, and others). In Portugal, electricity generation is totally opened to competition, subject to obtaining the requisite licenses and approvals. Electricity generation results in two types of remunerations: ordinary generation remuneration, which refers to the generation of electricity through traditional non-renewable sources and large hydro-electric plants, and production under special remuneration (PSR), which refers to the use of alternative endogenous and

renewable sources for electricity generation, cogeneration and microgeneration. Electricity producers under the scheme of the ordinary remuneration can sell the electricity produced to final consumers, or alternatively to the suppliers of electricity. On the other hand, electricity producers in special remuneration are obliged to sell electricity to the grid. The government creates the conditions for the development of the electricity market, guaranteeing its supply and the production capacity required. The security of the energy supply is also ensured by the Directorate General for Energy and Geology (DGEG).

The transmission system is responsible for the operation of transmission assets such as lines, cables, transformers and reactive compensation devices. This equipment connects production units to consumers and it is operated according to the instructions of the system operator that is responsible for assuring the equilibrium between supply and demand. Electricity transmission activity is carried out through the national transmission grid, through an exclusive concession granted by the Portuguese state to REN.

Furthermore, electricity distribution companies distribute the electricity received from the national transmission and distribution grids directly. The national distribution grid is operated through an exclusive concession granted by the Portuguese state. Presently, the exclusive concession for the activity of electricity distribution in high and medium voltage has been awarded to EDP Distribuição. The low voltage distribution grids continue to be operated under concession agreements awarded by municipalities primarily to EDP Distribuição.

The marketing activity is free, subject to obtaining the requisite licenses and approvals. Under the new electricity framework, consumers are free to choose their retailer, and may switch retailers without incurring any additional charges.

A regulated tariff remuneration is still available for all customers in Portugal, who are free to choose between the liberalized market and the regulated market, which is operated by EDP. This company plays the new role of energy Supplier of Last Resort, which is subject to regulation by ERSE, the Energy Services Regulatory Authority.

Supplier of last resort is responsible for the protection of remote customers is precisely to ensure that the consumer receives electricity supply, when this cannot be ensured under normal conditions. This competition between regulated tariffs and liberalized market is temporary, and provisions to limit the scope of application of last resort tariffs to small clients have been approved by the Portuguese and Spanish Governments under the framework of MIBEL.

The value chain of the electricity sector in a model centralized generation is divided into four areas: generation, transmission, distribution and supply. With the growth of distributed generation will occur structural changes in the value chain of the electricity

sector. The energy generated in the buildings does not require transmission lines as the current, which carry electricity over long distances. On the other hand it is necessary to manage flows of electricity with smart grids because it is necessary manage the balance between electricity sold to the grid and consumed.

The deployment of smart grid represents a profound change in the business model of the electricity sector.

A new energy paradigm is emerging, for which the electricity is produced close to the consumers in a decentralized generation (MEI 2007; Strachan N. and Farrell A., 2006). In the paradigm of distributed generation, the distribution is replaced by competence of the management of smart grids and development of new distribution systems. Services will be responsible for performance contracts, sale and maintenance of equipment, acquisition and sale of excess energy and consulting on energy efficiency.

POLICY AND LEGISLATION IN PORTUGAL

The concept of micro generation is growing in popularity as a sub-sector in Europe's strong market for renewable energy. Following the European Union energy strategies and recommendations, national governments are encouraging microgeneration related investments. In fact, national governments play an important role on the effective introduction of microgeneration technologies in the markets and daily life of citizens. In the National Plan for Action on Energy Efficiency (NPAEE), the extensive use of microgeneration technologies in a decentralized electricity system is presented as one possible system to meet the future objectives of the Portuguese government for the energy sector. Several incentives were developed a few years ago with the creation of a legal framework for energy efficiency requirements in buildings and lately with new legislation on micro generation that outlines production and compensation conditions. Portugal is an extremely active country on the renewable energy area and household microgeneration is a promising energy option showing high growth potential from the investors and population general acceptance perspectives. The market for micro generation in Portugal includes applications for micro-wind, solar thermal, photovoltaic (PV) and cogeneration heating in buildings. Portugal is also looking to benefit from expertise in project design and integration of micro generation into buildings. In order to accelerate the implementation of these measures, national authorities are obligated to decision making at policy level, economic and social. This integrated strategy is creating conditions for rapid and sustainable growth of renewable energy.

Portuguese government published some legislation to regulate the access to this system and the electricity selling tariffs. In November 2007, Decree-Law 363/2007 was published, regulating electricity generation through microproduction and establishing attractive feed-in tariffs for specific technologies. This

program aims to encourage the replacement of fossil energy consumption by renewable energy, through the increasing access to microgeneration technologies and solar heating. New rules and changes in the selling price for private production of electricity were introduced in October 2010 with Decree-Law 118-A/2010. The new rules included the increase on the amount of electricity that can be produced and the simplification of the registering process, now done in sequential order. The annual power attributed to the sector was increased to 25 MW.

In 8 July 2010, it was also approved by the Council of Ministers the National Energy Strategy which sets new targets for renewables and energy efficiency in Portugal. These incentives for decentralized energy production from renewable sources are also outstanding the minigeneration. The current system of incentives and subsidies to increase the residential microgeneration was extended to the Sector Business Industry and services through the minigeneration plan. Promoting Energy Efficiency by PMEs is vital to ensure external competitiveness. The creation of an industrial cluster in the area of renewable permits to boost the economy and is also an opportunity to tackle the debt and external dependence. The minigeneration has regulated by DL n.º 34/2011 of 8 of March, and involves the installation of power units with up to 250 kW, and provides a special remuneration, similar to the program "Renewable at the Time". This measure allow a good return on investment and open new opportunities of investment to investors/producers, such as schools, municipalities, which can produce energy in a decentralized manner. This resolution also assumes a production quota of 500MW until 2020.

LEGAL FRAMEWORK, SUPORT AND INCENTIVES

In Portugal, this reality began regulated by the Decree-Law n.º 68/2002 of 25th March. However, these regulations not contributed to a significant increase of micro generation in Portugal. This legislation present a complex administrative and technical procedures, negligible amount of grid connected microgeneration.

To reduce bureaucracy and simplify access to small producers the government created the program "Renewable in Time". For licensing scheme it was created an electronic platform (*SRM - Sistema de Registo da Microprodução*) which improved the interaction between producers and the administration.

A new legal framework for microgeneration, Decree-Law 363/2007 of 2 November, with specific legislation for grid connected microgeneration plants, attractive feed-in tariffs for specific technologies, simplified licensing process with easy internet registration, certified equipment (e.g. inverters) regulates the microproduction of electricity from renewable energy sources. The microgeneration defines two regimes of selling energy to the grid: the general regime applicable

to any type of microgeneration (or co-generation) source, limited to 5,75kW, the feed-in tariff is the regulated tariff defined annually by the national Energy Regulator; and the special regime exclusively for renewable sources: solar PV, wind, hydro, biomass, fuel cells (provided the hydrogen is produced from renewable energy sources), limited to 3,68kW interconnection power. The special tariff varies according the technology, with the following individual percentages: Solar (100%), Micro-wind (70%), Mini-hydro (30%), Biomass cogeneration (30%), Combination of energy renewable sources (average calculus of each individual percentage), and the Cogeneration based on non-renewable energy source apply the general remuneration. This special tariff (0,65 €/kWh) is valid only for the first 10MW installed all over the country. Afterwards from each 10 MW installed in the country the special tariff decreases in 5%. The tariff is constant during the first 5 years and then it is updated by the current year new contracts' tariff until 15 years. There is also a maximum limit of electricity produced by these systems that is remunerated, which corresponds to 2,4 MWh/year for photovoltaic energy and 4 MWh/year for the wind energy for each kW of power installed. The limit predicted is initially fixed to 10MW (in 2008) and is increased, each year, by 20%. To be included in special tariff it is also necessary to install a solar thermal collector for water heating, with a minimum of 2 m², or in the case of condominiums, an energy audit of the building.

However, the formality of the decree law 363/2007 had some limitations, especially with regards to the difference between the online request to install microgenerations systems and the inspections to the final installation. This situation means that many microproducers engaged the online project does not lead to the end, which means the high demand has lead to speculation block the request online. The new legal framework of the production of electricity requires payment upon registration, committing since the beginning. This factor combined with the need to update the rates mandated the creation of a new legislation.

In October 2010, the government launched the Decree Law 118-A/2010, this legislation increase the amount of electricity that can be produced through microgenerators, imposing an obligation on all suppliers of electricity in general to acquire electricity generated through microproduction. This legislation establishes mechanisms to ensure access to microgeneration by organizations supplying social services and organizations engaged in defense and security and other State or municipal services, simplifies the procedures of registration of microgeneration production, adjusts the subsidized scheme of sale of electricity and relates such scheme to the implementation of energy efficiency measures, establishing a requirement that the place of consumption be equipped with thermal solar collectors, biomass boilers or, in the case of condominiums, energy

efficiency measures found through examination. Changing the selling price and acquisition, increase the amount of electricity that can be produced and simplified the process of registering, which changed to a sequential order. This decree-law increased the annual power to 25 MW but maintained the two remuneration categories. The special remuneration is implemented for 15 years for facilities with a maximum power connection to the grid of 3,68 kW, which need to install at least 2 m² of solar collectors for heating water, or a biomass boiler. For condominiums with microproduction facilities up to 11,04 kW, it is needed an energy audit and the implementation of corrective

measures. In the first eight years, the energy is sold at 0,40 €/kWh (400 €/MWh). For the next seven years it is paid at 0,24 €/kWh (240 €/MWh). After the 15 years period, the producer enters in the general remuneration. The value of the tariff is calculated according with the technology applied: Solar (100%), Micro-wind (80%), Mini-hydro (40%), Biomass cogeneration (70%), Combination of energy sources (average of individual shares), and Cogeneration based on non-renewable energy source (40%). Table 1 presents the tariffs for microgeneration according the DL 363/2007 and DL 118-A/2010.

Table 1 - Applied tariffs for microgeneration in Portugal

Type of energy	DL 363/2007		DL 118-A/2010		
	Tariff reference (%)	Reference [€/MWh]	Tariff reference (%)	First period [€/MWh]	Second period [€/MWh]
Solar	100	650	100	400	240
Wind	70	650	80	400	240
Hydro	30	650	40	400	240
Biomass with Cogeneration	30	650	70	400	240
Cogeneration non renewable source	-	-	40	400	240

DISCUSSION

In order to achieve the supply capacity defined by the renewable program and the goal of installing 250 MW in microproduction at 2020 it was made an update of DL 363/2007, through the DL 118-A/2010 establishing more ambitious targets through the introduction of a miniproduction program. Miniproduction projects, up 250 kW, are directed mainly to the services sectors (schools and public buildings) as well to the industry. The target of the program of miniproduction is to install about 500 MW by 2020, with the possibility of delivery the entire production in low and medium voltage (ENE 2020).

The strong preference for solar PV microgeneration systems reflects incentives and a very good sun irradiation, 99% of microgeneration market in Portugal (MEI, 2011). This is the reason why is presented the case study for this technology, the new legislation with an increase in the rate of micro-wind (goes to 80%) could contribute to a better rate of penetration of micro-wind. The combination of renewable sources in energy production is not usual, however it appears in the decree law and may be an important way of satisfy electricity needs of small consumers.

The response from promoters, in less than one year was 1238 microgeneration units connected, corresponding to 4,3 MW. The first 10 MW (by the end of Mar/2009) was achieved by 2820 microgeneration units completed and pending certification/connection. The Government intends to achieve 165 MW (corresponding to 50000 microgeneration installation) of installed power in microgeneration, in 2015, almost the equivalent to the power of a large dam. In a scenario of maximum allowed installed capacity the evolution of reference

tariff moves from 650 €/MWh to 300 €/MWh in 2015 for photovoltaic energy (Quelhas A. 2009).

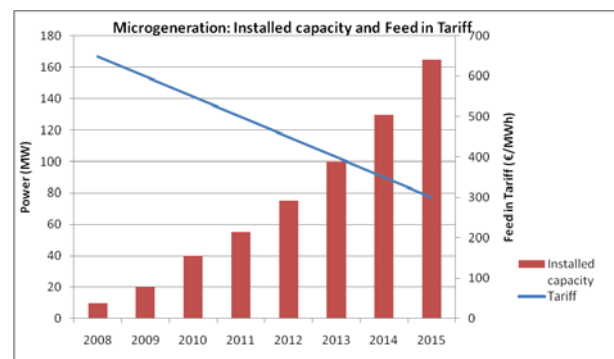


Figure 2 – Evolution of installed capacity and expect tariff at 2015

The “Renewable in Time” introduced a generous feed-in tariff that created conditions for the development of a small-scale microgeneration system market in Portugal. Motivated by economic and environmental concern, the program “Renewable in Time” was accepted with some interest by general public, according to the data publically available.

The online request has no correspondence to the level of the facilities. Indeed, for the first 10 MW, only 43% of all records corresponded to installations for which they were made inspection requests, and in the second 10 MW this value was 30%. This reality means that many microproducers engaged the online project does not lead to the end, which means the high demand has lead to speculation block the request online. The figure 3 illustrates this situation.

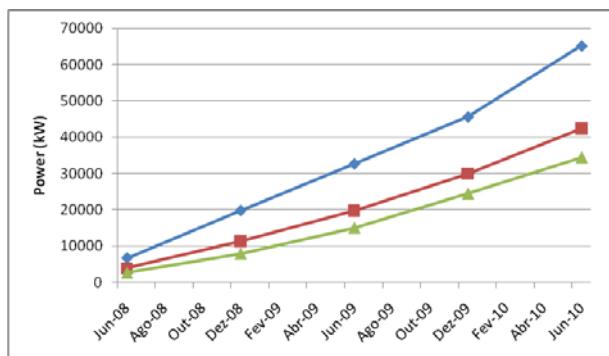


Figure 3 – Cumulative data. Online requests (blue), pay requests (red line) and inspection requests (green line) during the Law 363/2007

The economic attractiveness of the microgeneration systems is still strongly dependent of economic incentives, feed-in tariff, given directly and indirectly from the governments. To be economically feasible, the power generated must be sold in its entirety from the supplier, valuing the energy more than if the consumed directly in the installation. Given the availability of several different technologies or investment opportunities, the evaluation of projects to decide what the most profitable is fundamental for the private investor. It is also a necessary condition to ensure

interest for the progressive deployment of new energy technologies and for sustainable growth of the electricity sector.

A small analysis can be done in order to see the attractiveness of the business. This project was used as an example based on both decree laws, the DL 118A/2010 and the previous DL 363/2007, in the situation more favorable. This simulation is applied for two places in Portugal, Guimarães in the north of country, and Portimão where the irradiation is more intense. An economic viability study was performed considering the life of the system equal to 25 years for PV system. Tariffs estimated for the following 15 to 25 years were obtained according 3% increase of tariff defined annually by the national Energy. The simulation of production of electricity was obtained with software Photovoltaic Geographical Information System (PVGIS) of Institute Environmental and Sustainability of European Commission. This results consider the actualization on investment on equipment cost and other assumptions in the installation of microgeneration system, and is possible understanding how technologies of equipment prices are lower in 2010. The results of the economic analysis of photovoltaic solar microgeneration is presented in Table 2.

Table 2 – Economic parameters for PV microgeneration system.

Economic Parameters	Guimarães		Portimão	
	DL 363/2007	DL 118A/2010	DL 363/2007	DL 118A/2010
Annual Production (kWh)	6120	6120	7460	7460
Investment (€)	25570	21235	25570	21235
NPV (€)	9467	3493	17012	8903
IRR (%)	10,3	7,2	14,3	10,3
Payback (years)	6,8	9,5	5,2	6,9
Emission (Kg of CO ₂)	2368	2368	2886	2886

For the results presented in Table 2, the economic indicators obtained show the feasibility of the microgeneration project in both cities, as well for two decree laws. Is economically more attractive with the DL 363/2007 and in Portimão (IRR of 14,3% and payback within 5,2 years), this is understanding with the reduction with tariff and with more sun radiation. For the worst case scenario these indicators decrease, with an IRR of 7,2 % and pay-back in 9,5 years. This scenario occurs in Guimarães with actual Decree law. This project considers a discount rate of 5%. As a final comment, even for scenarios with features less attractive than those currently used, this

type of solution for energy production is an investment valuable.

The registration of the facilities under the special regime can be done online (www.renovaveisnagora.pt). This system has been developed to simplify the process of licensing, however, suffered several problems since it cannot control the demand. Registration is open for a short period and most of candidates for microproducers cannot register, what has caused stagnation after the initial growth. Table 3 presents a resume and compares tariffs on special regime by DL 363/2007 and DL 118-A/2010.

Table 3 – Comparing DL 363/2007 and DL 118-A/2010

	DL 363/2007	DL 118-A/2010
Selling price	1-5 years – 0,65 €/kWh, include year 0. 6-15 years – The fare of the year. ≥ 16 years – general regime	1-8 year - 0,40 €/kWh 9-15 year - 0,24 €/kWh ≥ 16 years – general regime
Reduced fare sale to new record	5% for every 10 MW of installed power	0,02 €/kWh per year.
Register	Need a pre-registration and throughout the year, the candidates tried to register the installation.	Sequential order of entry, spread over the year.
Rate of SRM	It was payable only could the register.	Paid at the initial registration
Limits of Power Connection	3,68 kW whether particular company or integrated into condominium	3,68 kW to private and corporate clients. 11,04 kW for condominiums with six or more installments.

Microgeneration legislation arises in Portugal in line of other energetic efficiency responding to the Europe efforts to reduce greenhouse gases emissions, and the objectives for renewable energy. The case study presented here shows that the legislation currently in use in Portugal adequately supports electricity to become microproducers of electricity, generating acceptable economic indicators for the return of investment for PV. This analysis demonstrates that these types of systems can be attractive contributing to spread the use of renewable energies in domestic and urban environments. For example microgeneration domestic sector could contribute as much as 40% to UK electricity demand by 2050 (Energy Saving Trust, 2005).

CONCLUSIONS AND FURTHER RESEARCH

This paper identifies regulatory and policy measures that could stimulate the market uptake of microgeneration technologies in Portugal.

The case study presents a analysis of the economic viability of photovoltaic system different places in Portugal with different solar irradiation, as well shows that the legislation currently in use in Portugal adequately supports electricity to become microproducers of electricity, generating acceptable economic indicators for the return of investment for PV. The economic attractiveness of the microgeneration systems is still strongly dependent of economic incentives, feed-in tariff, given directly and indirectly from the governments.

Currently the microgeneration systems to be economically feasible, the power generated must be sold in its entirety from the supplier, valuing the energy more than if the consumed directly in the installation.

The Payback, IRR and NPV values depend on different factors. In particular, the value of solar irradiation, very different from different locations in the same country, this conclusion is also obtained in the work of Dusonchet and Telaretti (2010). However, our study concludes that these systems will strongly dependent of policies and governmental incentives, and to be more attractive it is necessary equipment more efficient and less expensive.

Comparing the average results of the economic indicators show the feasibility of microgeneration project in Guimarães and Portimão for both legislation. However is more attractive in Portimão with DL 363/2007 (IRR of 14,3% and payback within 5,2 years), For Watson et al (2008), economic payback is not the only factor that influences micro-generation investment decisions, risks associated with energy prices and the reliability of new technologies are particularly important. However some evidence that economic barriers are the most important impediments to micro-generation (Energy Saving Trust, 2005).

The project will now proceed with further analysis of economic viability of microgeneration systems

connected to the grid in the light of current legislation in Portugal, with other technologies (wind and cogeneration), taking into account the expected costs and returns to the investor.

Beyond this, a broader view of the evaluation is attempted and the impact of microgeneration in Portugal is analyzed considering three fundamental dimensions: (i) macroeconomic and social impacts, focusing on wealth creation and employment generation, (ii) environmental impact, to the level of CO₂ reduction, and (iii) potential reduction of energy dependence.

On the other hand a comparatively address the development of microgeneration in Portugal and the EU framework. The legal framework is analyzed along with the incentives and tax benefits for different microgeneration technologies. Elaborate a detailed analysis and to discuss the Portuguese legal framework in order to ascertain the main features of these frameworks that may induce the project success or failure and the role of the defined payment rates.

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DECISION-MAKING PROCESS IN INVESTMENT PROJECTS

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ABSTRACT

We present projects evaluation approaches in what decision should be based. We try to understand what we have to take into account in a project analysis, knowing that we have to consider much unmeasured aspects, like non non-financial areas. We verify how all aspects are used and analysed in the project appraisal. We also desire to understand if companies have adequate tools and methods to correctly analyse and to take decisions in a project evaluation.

In this study we identify several aspects that are able to influence investment projects evaluation and decision-making process. An investment is not a mere financial activity, but involves a diversity of behavioural factors, organizational and business perception, which should be properly adjusted to invest with success. Investment decision-making should take into account non financial aspects, mainly, through some evaluation's format and method. As non financial aspects have an intangible nature, they are difficult to estimate, and cause a subjective analysis to project evaluators, it is important to develop an objective and tangible method that incorporates and quantify all non financial aspects together in project evaluation.

1. INTRODUCTION

The decision making in project investment is not difficult to do when we apply financial knowledge. Traditional financial theory use NPV, IRR and Payback period methodologies in investment decisions. Simultaneously, we can make a project risk analysis using sensitivity analysis and probability analysis. However, cash flow based analysis also present some limitations. Chen (1995) evidence that when the knowledge about new future investment is little, when operational environment forecasts is weak, or when we analyse investments with many intangible and uncertain factors (difficult to measure), the uncertainty and risk increase, affecting the difficulty of operational cash flow forecasts. The discount cash flow criteria frequently under estimate investment opportunities and does not

consider any strategic and other variables, creating myopic decisions and potential competitive losses.

Lopes and Flavell (1998) refer that investment decision is relatively simple in case of only financial criteria are taken into account. However, the decision can be much more difficult to take when we consider other aspects than financial ones. In a way of taking the best investment decision, it is required information about all areas that can influence this decision. It is important to understand how all non financial aspects can be used in project appraisal, knowing that this could not be easily measured in monetary terms.

We have to consider that there are many aspects to be analysed in a project to take a decision. Skitmore at al. (1989), Adler (2000), Chen (1995), Meredith and Mantel (2000), Love et al. (2002) and Lopes and Flavell (1998) present some non financial aspects, in addition to financial aspect, that have to be consider in the project appraisal. Moutinho and Lopes (2010) have summarised the aspects to be analysed in an evaluation investment process as the following: financial, strategic, technical, commercial, political, social, environmental, organizational, and human resource plus management. In one hand, each one of these non financial areas can influence project financial analysis and, in other hand, these areas can provide additional relevant information to the decision making and, in another hand, these aspects can affect the implicit risk through the discount rate. To analyse all this areas together is important to know and understand some methods and tools that allow us to decide which projects to undertake.

The importance of each of these areas of analysis and critical success factors for each of the areas in the projects depends on the companies, projects, management and project manager characteristics.

The best way to analyse a project investment is to take into account all previous non financial areas. However, these financial and non-financial aspects may not take into account information and incentive problems that can emerge in a firm, because decision-making depends of people reports with its own interests and private information about the project. There are other aspects that have to be considered in an investment decision making: management and governance. Thus, in a project appraisal decision making we should also study the project capital structure, the agency problems, the governance and the postponement option.

Specifically, our study has three principal objectives. The main goal is to understand what we have to take into account in a project analysis, knowing that we have to consider much unmeasured aspects. The idea is to identify the important aspects to be considered in a decision-making. The second objective is to verify how all above aspects are used and analysed in the project appraisal. We also present some methods that take into account these aspects in a project analysis. The last objective is to understand if companies have adequate tools and methods to correctly analyse and to take a decision in a project appraisal.

This paper is organized as follows. In next section, we show how various aspects can influence project decision making. In section three we present the research methodology. Section four includes the results analysis about project decision making process. Finally, we present our conclusions.

2. DECISION-MAKING CHARACTERISTICS

Evaluation of Financial Aspects

Investment decision is done at the beginning and it depends of the final value being superior to the total investment. Gitman and Forrester (1977) refer that evaluation methodologies can be considered into two groups. For one hand, project performance is measured with accounting data. Payback period and accounting profit rate are also considered in this group. However, these evaluation methods are inadequate because problems associated with accounting data. In other hand, we have to consider cash flow criteria in project evaluation. The investment decision is measured by Net Present Value, Internal Rate of Return and Index of Profit Value. This second group of evaluation criteria are being more used than the criteria based in accounting dates.

Based in risk analysis, we can obtain information about aspects that affect projects. Many times this analysis is subjectively evaluated by the companies (Kim et al., 1986; Schall et al., 1978; Ho and Pike, 1991). In Portugal, around 20% of companies do not perform risk analysis in the project scope (Rodrigues, 1999). This can mean that companies do not intend to measure risks but identify sensible variables to the risk (Pike, 1996). Despite of these results, Ho and Pike (1991) consider that the use of probability analysis and simulation analysis approaches can offer a bigger level of confidence in final decision.

The risk analysis is done, many times, through adjustments in the discount rate or cost of capital or through cash flows adjustment and use a free risk discount rate (Ho and Pike, 1991; Petry and Spow, 1993). Freeman and Hobbes (1991) and Petry and Spow (1993) show that many companies (47% and 30%, respectively) use the same discount rate for all projects. This is a signal that companies do not pay any attention to project evaluation risk. By the contrary,

Poterba and Summers (1995) assure that companies adjust the discount rate according to the project type.

Evaluation of Non Financial Aspects

The analysis and the incorporation of non financial aspects in decision making can be explored in three perspectives: how non-financial elements of the project are evaluated; the method used to quantify non-financial (qualitative) aspects in project evaluation; and the trade-off policy.

In relation to how non-financial elements of the project are evaluated, we have to consider various factors. Lopes and Flavell (1998) evidence that decision-makers experience in other projects is important for risk evaluation, doing through maintaining records of past evaluations to verify the credibility of management opinion. In other way, to avoid a qualitative evaluation much dependent of persons, of its personal experience and comprehension, companies must create a register of its own past experience and generate checklists of analysis of all aspects. These analyses should be systematic, rigorous and incorporating people from several backgrounds. The examination can be done using external advisors in project appraisal. The qualitative project appraisal should not have a standard-format, but a free-format qualitative evaluation. If projects are incorrectly analysed by management, it is important to define alternative strategies and consider all risks.

Nardini (1997) suggests that for non financial aspects companies can use a multi-criteria analysis of the projects. This analysis presents various advantages: non economic character of its valorisation; abilities to surpass various and conflicting issues; and structure problems of complex decisions, increasing its transparency. Esperança and Matias (2005) present ELECTRE method as the multi-criteria model with more application.

Lopes and Flavell (1998), relatively to the method used to quantify non-financial (qualitative) aspects in project evaluation, state that these methods are much dependent of personal opinions and perspectives. It should have combination between personal analysis and personal opinion, because this provides support information to decisions and influence risk probabilities and its consequences. It is essential good sense for assessment and identification risk factors, as well as assessing effects and risk probabilities. The decisions are justify through discussion of arguments of all aspects analysed in inter-relation. Although it is not well understand in practice, companies can create lists of risk indices, attributing a qualitative weight to each item. The success of these process depend of the personal experience, of the feedback of past projects, of the systematic and detailed analysis of expert support and of the people from several backgrounds and its relation with decision

making. Companies can also create checklists as risk warning to decision-makers.

Nardini (1997) refers that the ideal appraisal process should have: a strength and weakness balance sheet, knowing that the decision is a trade-off between conflicting criteria; comparing alternatives is a prerequisite to obtain a negotiated solution; scenario creation about future that permit to "choose the alternative that, in the most probable scenario, has the best performance"; an evaluation indices on the way to represent quantitative and qualitative impacts (that should permit the construction of an alternative top ranking); an analysis of all different impact category and of each alternative, connecting all affected people, and making all aspects the most quantitative as possible; negotiation as a process of conflict resolution; cost-benefit analysis; and public participation.

As a process to take decisions, Ghotb and Warren (1995) present two methods that study qualitative and quantitative aspects together: Analytic Hierarchy Process is a simple manner to combine qualitative ratings with quantitative measures to obtain priorities for the alternatives; Fuzzy Decision Methodology use common words to make the rating and transform this linguistic variables in fuzzy sets to the subsequent operations. On the other hand, Lefley and Morgan (1998) and Lefley (2000) present the Financial Appraisal Profile model that includes the principal aspects of investment decision making: financial aspects, risk feature and strategic side.

In respect to the trade-off policy, Lopes and Flavell (1998) refer that all risks should be balanced and the company has to verify which can be faced. All great identified risks should have solution, and companies should have established minimum requisites with the goal to maximize the viability of all areas. In this way, the trade-offs has maximum limits (risk company capacity) and practical limits (it is not possible to have the best standards in all areas). Companies have to have very careful with the trade-offs related with the cheapest way (it is need to conjugate the best solution with price, using the price-quality analysis). It is essential to reminder that each project and each industry has its own risks and policies that depends of timing and localization.

Project Capital Structure

Relatively to the way a corporate finance its activity is important to consider that the company's value is affected by the capital structure employed. In this way, we can analyse if there is an optimal capital structure: the one which maximizes the value of the firm. For beyond the importance of investment decision, it is important to know that is very important the way projects are financing. So, the debt policy and financing decisions are important for the project viability.

Agency Problems

Investment decision analysis does not usually consider incentives and information problems that can emerge by the fact that decision depend on the reports of people with its own interests and private information about the quality of the project. Investment decision can be influenced by agency problems and by asymmetric information between the decision makers (management) and capital owners (shareholders). Investment decision distortion can happen because of the misalignment of management and shareholder interests (Jensen and Meckling, 1976; Jensen, 1986), and because information asymmetry between insiders and capital markets (Myers and Majluf, 1984). Both motives become investment sensible to the available resources in the company. Jensen (1986) and Stulz (1990) refer that companies with more cash flow (companies are going to preserve free cash flow instead of pay dividends to shareholders) have more propensity to investment realizations, many times not lucrative – managers over-invest for private benefits. The over-investment increase the agent power through resources enhance under his control and arises, many times, associated to bigger manager's compensation (Jensen, 1986).

Management investment decisions in presence of imperfect information and short term management goals– due to the incentives/compensations and to the fear of loss control – guide to the sub-investment in long term projects and to the over-investment in short term projects (Bebchuk and Stole, 1993; Bohlin, 1997). The threats of hostile takeover and subsequent management unemployment show the way, also, to myopic investments (Knoeber, 1986). On the other hand, Noe and Rebello (1997) refer that managers prefer long term instead of short term projects because of their long-standing in company due to its importance for the success of the project. Bernardo et. al. (2001) show, that in presence of asymmetric information and moral hazard, managers with investment projects of higher quality will receive more payments incentive based than managers of projects with lower quality.

In a project analysis study there is another perspective of agency problem. According to Turner and Muller (2003), the company management (management) faces, basically, two problems in his relationship with the project manager (manager): by one hand, there are asymmetric information because managers has private information; on the other hand, as manager possess his own objectives, can arise opportunistic behaviours that drive to conflicts of interests with management.

In a way of decrease agency problems and for managers to make efforts and really reveal its private information, it should be create incentives to align managers' objectives and should adopt control mechanisms to prevent the opportunism. In respect to incentives, contracts can be based on results and on behaviour. The incentive contracts can be by sharing ownership and by

stock options (Jensen and Meckling, 1976; Fama, 1980). It is also important to improve the circulation of information, with implementation of a complete information system, to increase managers' actions and results under monitorization (Turner and Muller, 2003) and to impose penalties for lower performances obtained, as manager unemployment and/or reputation reduction, that has negative impact in manager future career opportunities (Jensen, 1986).

Governance

For beyond agency problems, also governance can pressure investment decisions. Malmendier and Tate (2005) evidence that CEO characteristics can create distortions in company's investment policy. Such as in Heaton (2002), this study show that distortions can be the result of too confident management and over estimation project returns by managers, mainly when they have free cash flow. There are some CEO characteristics that can pressure investment decision making: education, experience (career area), birth generation and position accumulation (CEO and chairman). Lundstrum (2002) evidence the relation between manager's age and its company investment decision. Chakraborty et al. (1999) show, also, that CEO compensation uncertainty has negative effect on investment level of companies.

Jensen and Meckling (1976) argue that ownership structure affects firm value by its effects in investment. Mork et. al. (1988) refer that the owner assumes management functions because of the firm value. Although ownership structure influence investment and firm value, Cho (1998) concludes that ownership may do not have an effective incentive mechanism on the way to encourage management to higher value investment decisions.

Real Option Use

One of the main elements that influence the expectations in investment decisions is the available information and its interpretation. Some times it is necessary to wait for more information because we need to reduce investment uncertainty and risk and because of the possible net present value future volatility. Carruth et. al. (2000) refer that uncertainty increase the postponement real option value. The investment decision can be postponed to wait for new information about market conditions.

In case of an irreversible investment, companies should consider the option of do not invest in that moment. The possibility of wait for new information can influence the arrangement or the moment for investment (Dixit and Pindyck, 1995). Considering the permanent reality change daily faced by companies, new information obtained can force strategic modification as adaptation to the market, with the goal of cash flows maximization. Thus, companies can choose several

kinds of real options: postponement; abandonment; change; dimension alteration; growth; combined.

As owners delegate investment decision option in managers, these have power to take such decision. In this way, the agents will have an option for choose the moment of the investment. Managers will have postponed options with more value than the owners (Grenadier and Wang, 2005).

Other Factors

Other factors can influence project investment decision making. Papadakis et al. (1998) present some factors that influence strategic decision making process, namely the investment decision. This study identify the following decision elements: specific characteristic of decision (nature of strategic decision and characteristics of decision process); demographic characteristics and CEO personality (need of conquests, risk attitude, CEO tenure and CEO education); top management team characteristics (grade of aggressiveness, dynamic or hostile environment); external environmental context (heterogenic, dynamic or hostile environment); and internal environmental context (intern system, performance, dimension and company control).

Bruijn and Heuvelhof (2002) refer the importance of all stakeholders, considering its different perspectives and interests, with the goal of considering different viewpoints, driving to an improvement in the quality analysis and in the decision-making.

Slattery and Ganster (2002) evidence management decisions as decisions where the effective consequences of subsequent choices are influenced by the results of past decisions. The effect of previous decisions that cause unsuccessful (success) can drive to less (more) risky decision-making later. With such uncertainty level and dynamic environmental decisions, risk taking can be determined by an affective process that change the profits and losses values and by a cognitive process that determines his level of confidence.

It is still important that project decision maker has attention to the following factors: create levels of decision and intermediary trade-offs, avoid emotional decision-making, promoting rational debates and avoid the domain of arguments by the persons of strong character. The best decision makers are humble, are not presumptuous and are conscious that is difficult not to be emotionally involved (Lopes e Flavell, 1998).

3. METHODOLOGY AND DATA

The data for this study were obtained from a questionnaire sent to larger Portuguese companies in 2005. This questionnaire is the same used in Moutinho and Lopes (2010). It was received 96 responses to the questionnaire, representing a response rate of 9,6%. Although we do not know the identity of the survey respondents, we do know some firm characteristics, as discussed below.

In our survey 39,4% of firms are in the manufacturing industry, 25,5% in the commercial sector and 17% are in transportation / energy sector. We verify that nearly half companies that implement projects have sales between 10 and 50 million thousand euros and 30% has sales superior to 100 million thousand euros. In respect to firm's total assets, 45% has until 36.245 thousand euros and 33% has more than 96.810 thousand euros.

We observe that 40% of projects are expansion investments, 32,7% are modernization investments and 13,8% are substitution investments. The project is implemented during 12 months and during a period superior to two years for 34% and 40% of companies, respectively. The investment amount vary as follow: 43% is inferior to 2,5 million thousand euros; 23% of companies invest between 2,5 and 7,26 million thousand euros; and, 35% invest an amount superior to 7,26 million thousand euros.

Relatively to CEO characteristics, we verify that 45% has between 46 and 58 years old and a majority (50%) has lot of experience as chairman of the board. We observe that in 45% of the companies more than 20% of the firm is owned by management, and in nearly half of the sample no part of the firm is owned by management (49,5%). We can also observe that 72% of project managers have no more than 50 years old.

4. PROJECT DECISION MAKING ANALYSIS

Evaluation of Financial Aspects

Project analysis has to consider traditional analysis taking into account not only sophisticated and unsophisticated analysis methods, but also risk analysis. Moutinho and Lopes (2010) report that IRR is the most important evaluation method. The companies also consider the net present value, the scenario analysis, the payback period and the ratio benefit/cost. The order of these results is similar to the results found in the Graham and Harvey study. In opposite, the evaluation techniques less important are breakeven analysis, simulation risk analysis, accounting rate of return and real options.

Evaluation of Non financial Aspects

Apart from financial analysis, it is need to consider all non financial aspects, which are difficult to measure. Moutinho e Lopes (2010) present the most important perspectives of analysis in a project appraisal. They evidence (see Table 1) the importance of the analysis of various non-financial aspects and show how some of those aspects have a greater relevance than that attributed to the financial ones.

The strategic and technical aspects stand out as the most relevant issues. The financial aspects are considered only in the third place of importance, together with commercial analysis. The least relevant areas were the social and political ones. The study also analyse the

environmental, the organizational, the human resource and the project manager area. In a way of doing non financial analysis, we have to know how this knowledge is integrated in a global investment analysis.

Table 1: Project Investment Analysis Techniques

What is the importance of each of the following areas in the project's valuation?	% Import and very Import	Average
Strategic	91,7%	3,45
Technical	86,5%	3,28
Commercial	75,0%	2,9
Political	20,8%	1,47
Financial	75,0%	2,97
Social	33,3%	1,8
Environmental	55,2%	2,3
Organizational	57,3%	2,43
Human Resource	53,1%	2,3
Project Manager	69,8%	2,71

Source: In Moutinho and Lopes (2010)

Analyzing Table 2 we observe that companies choose, as main tools of non financial aspects evaluation, the incorporation people from several backgrounds (43,8%), the free-format qualitative evaluation (39,6%), the experience of evaluators/decision-makers in other projects, collected by several companies (36,5%) and the using of external advisors (35,4%).

Table 2: Evaluation of Non-Financial Elements

N=96	%
Free-format qualitative evaluation	39,6%
Checklists of analysis of non-financial aspects	31,3%
Past experience in risk assessment, gathered by several companies	24,0%
Maintaining records of past evaluations	20,8%
Experience of evaluators/decision-makers in other projects	36,5%
Using external advisors	35,4%
Incorporating people from several backgrounds	43,8%
Considering management's errors of judgement in non-financial evaluation	4,2%
Considering management's errors of judgement in risk assessment	5,2%

Relatively to incorporation and quantification of non financial aspects used, from Table 3 we observe that companies has preference for discussing and assessing favourable and unfavourable factors to the project's execution (77,7%). There are still others methods that deserve company's emphasis: coordinated analysis of financial and non-financial aspects (55,3%) and identifying risk factors and assessing effects and risk probabilities (51,1%).

Table 3: Methods used to quantify non-financial (qualitative) aspects in project evaluation

N=94	%
Identifying risk factors and assessing effects and risk probabilities	51,1%
Discussing and assessing favourable and unfavourable factors to the project's execution	77,7%
Coordinated analysis of financial and non-financial aspects	55,3%
Requesting opinions from each area and verification of consistency with the company's	35,1%
Creation of lists of risk indices, attributing a qualitative weight to each item	6,4%
Attributing positive and negative considerations to	13,8%
Dividing factors into levels of importance for subsequent evaluation	5,3%

Project Capital Structure

In a project analysis is always important to consider how to finance. Companies that answered the survey refer that their projects are, on average, 62% financed by equity capital and 38% by debt. As debt financing companies use bank loan, public financing, leasing, venture capital and financing of European Investment Bank. In our sample companies do not choose equity capital through going to public but they perform new capital through capital increased for project financing. In what respect to the discount rate used, Moutinho and Lopes (2010) evidence that the company's cost of capital and the project's cost of capital are the most used. These methods appear in the same order of use like in Graham and Harvey (2001) and in Brounen et al. (2004).

Agency Problems

When investment decisions are delegate to managers, contracts should be designed with the goal of provide incentives for management to make efforts and reveal its private information.

As it can be verified on the Table 4, around half of the managers have lot of experience in project management (more than four) and more than half of managers have fixed reward as compensation form – his normal salary. Managers do not earn on the basis of more elaborate compensation plans. However, some companies built different compensation forms as the following cases: reward associated with goals for each stage, reward associated with the percentage of completion and reward associated with the conclusion of the project.

Governance

It is also important to know who takes investment decision-making to identify how influence is exercise in respect to several stakeholders, to be exact the internal stakeholder. The investment decision making is able to

influence firm value and ownership structure may has an effective incentive mechanism on the way to encourage management to higher value decisions.

Moutinho and Lopes (2010) finds that companies' management is the main project implementation decision maker. They have identified others stakeholders that take this decision, however companies' management is, from far away, the main responsible by the decision. Portuguese companies have also appointed shareholders, chief of financial officer, project manager and commercial director as investment decision-maker.

Table 4: Management Compensation

Panel A - Experience in Project Management (N.º Projects)

N	Zero	One	Two	Three	Four	> Four
85	3 3,5%	5 5,9%	11 12,9%	14 16,5%	9 10,6%	43 50,6%

Panel B - Compensation's Form of the Project Manager

N	% of completion	goals for each stage	Fixed	Other	No One
86	2 2,3%	12 14,0%	49 57,0%	16 18,6%	7 8,1%

Real Option Use

Given the permanent reality change daily faced by companies, new information obtained can force strategic modification. Companies could have to wait for more information because of investment uncertainty and risk. Thus, companies can choose several kinds of real options.

In respect to real options analysis, less than half of the companies use this methodology. Of the companies that use this technique, Moutinho e Lopes (2010) verify that they take in consideration, preferentially, the implications in future projects, changing inputs and changing outputs. Although we verify that "little importance is attributed to real options in project appraisal, we also confirm that these options are considered in the process of analysis. This might mean that firms do not consider the real option methodology in a conscious way" (Moutinho and Lopes, 2010).

Other Factors

There are other factors that can influence project investment decision making. Thus, we seek for issues that influence decision maker and project's goals with the aim of identify features that we do not have focus in the other aspects cited above. We verify dispersion and diversity of critical factors, as well as identify factors of several areas of analysis in this study.

From Moutinho and Lopes (2009) we verify that various non financial aspects were considered critical in project

evaluation. The issues with more relevance to project are the technical, strategic and financial aspects, followed by other non-financial aspects. Further than financial and non financial areas, companies mention “deadline”, “quality”, “customer’s satisfaction”, “quickly implementation” and “partnership with costumer”.

5. CONCLUSIONS AND FURTHER RESEARCH

In this study we identify practices of companies in investment projects decision-making. Given the limitations from the use of traditional evaluation techniques in project analysis – resultant of non incorporation of subjective, intangible, and qualitative nature aspects – we remain that others factors can affect the projects’ implementation. So, an investment is not a mere financial activity, but involves a diversity of behavioural factors, organizational and business perception, which should be properly adjusted to invest with success.

Investment decision-making should take into account not only the traditional evaluation criteria, but also non financial factors, through incorporation people from several background, free-format qualitative evaluation, experience of evaluators/decision makers in other projects, the uses of external advisors and create checklists of analysis of non-financial aspects. As method for incorporation and quantification of non financial aspects in the project evaluation, companies mainly choose the discussing and assessing favourable and unfavourable factors to the project’s execution, a coordinated analysis of financial and non-financial aspects and identify risk factors and assessing effects and risk probabilities.

Non financial aspects have an intangible nature, are difficult to estimate, and cause a subjective analysis to project evaluators. In this way, investment decision-making only reflects, often, financial techniques. In that sense, it is important to develop an objective and tangible method that incorporates and quantify non financial aspects in project evaluation. Therefore, it is important to analyze various methods, and its application to the projects, which help in the decision-making as the Analytic Hierarchy Process, the Fuzzy Decision Methodology, the Financial Appraisal Profile, the multi-criteria analysis, the ELECTRE method and the cost-benefit analysis. Due to the influence of risks in cash flows adjustment and discount rate, it is important to build a model that is going to identify and evaluate risks of non financial nature in a structured way.

For beyond the areas referred above, there are another five aspects that can influence the feasibility of the project and the investment decision making. First, the project financing is, mainly, made with equity capital (that can influence the discount rates, the debt fiscal advantages, the agency and bankruptcy costs, as well as the management and stockholders attitude with the

project). Second, managers are not reward with advanced compensation plans, but on the basis of their normal remuneration. This can influence their efforts with the project, given their interests are potentially different from the company ones. Third, the project implementation decision is taken, mainly, by the companies’ management. Fourth, the investment postpone decision can be important with the purpose to obtain more information. The use of real options methodology can be relevant for project value. However, implications in future projects, changing input and changing outputs are the most relevant options for the companies analyzed. Finally, there are diverse critical success factors from several areas.

In this sense, are company’s correctly analysing projects? Are companies really making rational investment decisions? Are companies taking all aspects of projects into the appraisal process? Do companies need to change the way they evaluate projects? Maybe companies need to reformulate the techniques that they use to make investment decisions. Maybe real options can help them to understand the non-financial aspects in this context, but is it enough for company’s decision? Are Analytic Hierarchy Process, Fuzzy Decision Methodology, Financial Appraisal Profile, multi-criteria analysis or ELECTRE method the best evaluation methodologies to analyse an investment project?

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PROJECT FINANCING AND VERTICALIZATION IN INFRASTRUCTURE PROJECT EVALUATION: A CASE STUDY OF ABENGOA

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ABSTRACT

The gradual transfer to private companies of public utility and infrastructure services has fundamentally changed the business environment for heavy engineering companies. This new competitive state of affairs has led these companies to assemble large investments in infrastructure assets. One that has adopted this new strategy is Abengoa – Spanish a firm focused on power generation, transmission and water utilities. Abengoa has been growing fast for many years, winning (in auctions) long-term public infrastructure contracts. The necessary infrastructure assets are built by Abengoa's engineering companies and construction is financed through highly leveraged financing structures, that include intensive use of Project Financing. Abengoa's case is particularly interesting because it allows us to understand how it is possible to build a highly leveraged capital structure, without compromising access to capital markets or hindering further investments in fixed assets. Abengoa's project evaluation model is also noteworthy as it combines in a single discounted cash flow both infrastructure project's cash flow and the gains obtained through vertical integration. This financial model also measures the impact of various types of debt, both at project level and at the corporate level.

INTRODUCTION

The gradual transfer to private companies of public utility services that once constituted public services or monopolies held mostly by state-owned companies has fundamentally changed the business environment for heavy engineering companies. Until the 1970's engineering companies used to be hired by public utilities or governments to build new infrastructure. But from the 80's, many countries started to promote public auctions for the provision of the infrastructure services themselves: toll roads, airports, power plants, water services, etc. The logic behind this policy change was that competition for the provision of infrastructure

services would lead to lower costs for consumers and, if proper regulation is place, could also result in better quality of service than the old concession or public service model.

With this policy change, competition for construction contracts moved to the actual bidding process for infrastructure assets. As public auctions for infrastructure services usually include the construction and maintenance of the infrastructure assets themselves, heavy engineering companies now take part in the bidding process for new concessions. This new business environment requires that engineering companies own some of the infrastructure assets they build, as construction contracts tend to be awarded to companies participating in the winning consortia in public auctions for concessions or for long term contracts for infrastructure services. Thus, participation in such consortia, often as a major investor, became vital to heavy engineering firms.

This new competitive environment has led companies that originally focused their activities on heavy construction to assemble large portfolios of infrastructure assets. Among the companies that have adopted this new strategy, several Spanish firms are noteworthy: Abengoa (power generation, transmission lines and water services), OHL (transportation), ACS (transportation) Isolux (transportation and transmission lines) and Elecnor (wind power generation and transmission).

The business model of these companies has as main characteristics:

- Rapid growth of the portfolio of concessions and contracts for infrastructure services;
- Aggressive pricing in public auctions for concessions and infrastructure services;
- The use of highly leveraged financing structures including intensive use of Project Financing.

The case of Abengoa is particularly interesting because this company discloses its financial strategy in detail and allows us to understand how it is possible to build such a highly leveraged capital structure, without compromising access to capital markets or hindering

further investments in fixed assets. This company has grown fast for many years, winning long term public infrastructure contracts and building the required infrastructure assets. Furthermore Abengoa's business model proved resilient as it resisted to the financial crisis that began in 2008: abengoa's growth was not halted and it did not lose access to debt markets. The feat is remarkable, because after the crisis financial markets severely penalized such highly indebted companies. Some performance figures are illustrative of the company:

- Revenue growth of 19% per year between 1999 and 2009. Revenue growth of 10% between 2008 and 2009.
- EBITDA growth of 24% per year between 1999 and 2009. EBITDA growth of 34% between 2008 and 2009.
- Shareholders' equity amounting to less than 10% of total assets in 2009.

The Abengoa's business model involves:

- The use of debts both at the project level (Project Financing) and at the holding company level (Corporate Financing).
- Vertical integration of activities, with operations both in the provision of infrastructure services and in the provision of services required by infrastructure projects (especially heavy construction).

This paper is structured as follows: after this introduction (1), section (2) presents the strategies adopted by heavy engineering companies. In (3) we make a bibliographic revision of corporate finance and project financing and finally, in (4) we present Abengoa's case study and (5) we conclude.

HEAVY ENGINEERING COMPANIES' INVESTMENT STRATEGIES

When playing a role as investor in auctions for concessions or for the provision of infrastructure services became vital to get construction contracts, heavy engineering companies faced the problem of funding the participation in new capital intensive projects. It is not a trivial issue, as companies with a business model based solely on construction tend to have little access to long-term capital.

A company specializing in heavy engineering has a highly cyclical business. On the ascending phase of the economic cycle, investment projects are plentiful and business growth in the construction sector tends to be far greater than GDP growth. But during the crisis, new projects are usually scarce and the portfolio of construction projects shrinks sharply.

Given the cyclical nature of heavy engineering business and the fact that projects are relatively short spanned (engineering projects with four years or more are uncommon) it is a kind of business that has trouble getting long term debt. Moreover, high uncertainty

regarding future cash flows makes raising equity for construction companies both difficult and expensive.

One strategy is to act as investor in infrastructure projects to ensure participation in the bidding process, only to sell the stake in the projects as soon as possible. The construction company acts as an investor to obtain a construction contract, but becoming an investor is not a long term proposition, as infrastructure services are not considered as a core activity. If the company adopts this strategy, it tries to sell its stake in the project to release capital for new projects that will bring new construction contracts.

Although this first strategy is perfectly feasible, it does have its drawbacks. The main one is that cash flows remain volatile and, therefore, access to long term capital is still an issue. Moreover, selling a stake in a new project can be difficult in a bear market and even in normal market conditions a good sell of such an illiquid asset may take quite some time. Therefore, one cannot really count on recouping equity committed to a new infrastructure project at a fixed date.

Another strategy, the one that Spanish several heavy construction companies adopt, is to become a long-term investor in infrastructure assets. It consists in building a corporate structure with both heavy engineering companies and companies dedicated to infrastructure services. Obtaining a construction contract is still one of the motivations for investment in new infrastructure assets. But construction is no longer the company's core activity, as ownership of infrastructure assets becomes a long-term commitment. This second business strategy explores the synergy between construction business and infrastructure services.

The first aspect of the synergy between construction and investments in infrastructure services is achieving a greater stability of cash flows. Predictable cash flows may serve as collateral for debt at the corporate level. Infrastructure projects usually have stable, non cyclical revenues which one can use as collateral to raise funds at the special purpose company level (SPC) to finance construction. But a portfolio of infrastructure SPC's generates a steady source of non-cyclic dividends that in turn can serve as a basis for raising long term debt at the holding company level. Of course, as dividends received by the holding company are subordinated to debts at the SPC level, corporate debts at the holding company level tend to be rather expensive. But the very ability to raise long term debt is a distinct strategic advantage over a dedicated heavy engineering only company.

The second aspect of the synergy between construction business and infrastructure services is vertical integration. Infrastructure companies always hire heavy construction companies to build infrastructure assets. But if they hire another company within the same group to provide construction services, there is a vertical integration gain. The same business opportunity, a concession of a toll road, for example, will generate cash flows for two companies belonging to the same

group: the SPC that owns the toll road and the construction company that builds it. Vertical integration gains render holding companies that own both concessions and heavy engineering companies very competitive in public auctions for concessions infrastructure services and therefore such auctions tend to be dominated by such companies and by consortia that include construction companies acting as long term investors.

The third aspect of the synergy between construction business and infrastructure services is the ability to manage construction budgets and construction payables in order to implement financial engineering strategies. Like most suppliers, construction companies are usually chosen through competitive bidding and, therefore, their construction budgets tend to be rigid. But if both the infrastructure SPC and the engineering company that builds its assets belong to the same owner, there is room to design a construction budget that will be the most effective one from a consolidated point of view. Notably, one can hire only suppliers that accept long-term trade payables, thereby releasing capital for other corporate needs.

As stated before, one of the main challenges for a company that plans to build its own infrastructure assets is to raise long term resources to finance the new assets. Project financing at corporate financing are the obvious choices. But if the company consistently achieves positive working capital from a consolidated point of view, working capital can also be an important long term source of cash. Positive working capital can be achieved if suppliers accept very long payment cycles, either through supplier's credit or through a scheme where banks are ready to discount trade payables issued by the construction company.

Of course this strategy has a financial cost, as suppliers will charge more if they are paid through long-term receivables. But the upside is that banks and rating agencies usually classify trade payables as operational liabilities and, therefore, do not find that they increase credit risk substantially.

All Spanish engineering companies that act as long term infrastructure investors fully explore all the three aspects of the synergy between construction business and infrastructure services. The largest of these companies is ACS. It followed this strategy with such commitment that has come to name itself after it (ACS stands for "Actividades de Construcción y Servicios" or Construction and [infrastructure] Service Activities). But other Spanish companies adopt the same business model: OHL, Elecnor, Isolux and Abengoa. All of them have:

- large portfolios of infrastructure services projects;
- at least one engineering company in the group;
- achieve high leverage through corporate debts at the holding company level and project financing;

- use working capital as a long term source of cash.

PROJECT FINANCING FOR INFRASTRUCTURE PROJECTS

This section presents the main features of Project Finance, which is one of the main financing structures used by heavy engineering companies in infrastructure projects.

Definition and History

We can define Project Finance (PF) as a financing structure, most appropriated to infrastructure projects, in which project assets and project cash flows are the main collaterals.

Nevitt & Fabozzi (2000) define Project Finance (PF) as financing to an independent economical unit, in which lenders are satisfied mostly with cash flows generated by this unit as the source of funds to pay the loan and the economical unit is given as collateral for the debt.

Esty (2003) points out that PF implies the creation of a legally independent company for the specific asset (project), which is financed through non-recourse debt.

The idea of financing a project having the cash flows generated by the project itself as collateral is not recent. In 1299 a Florentine bank financed a silver mine project owned by the British crown in Devon having as collateral only the mine production. Other examples are European commerce with Asia in the XVIIth century, which was financed through a stake in the value of transported goods. In the 1930's, loans for oil drilling in Texas used to be paid with oil production. In the US Electricity Industry a big step was taken in 1978 with the approval the Public Utility Regulatory Policies Act (PURPA) by the Congress, through which utilities were to sign long term contracts with independent power producers that used renewable sources, such as wind and solar power production, and energy-efficient thermal processes such as cogeneration units. These projects used to be Special Purpose Companies (SPC) that took non-recourse loans.

There are two ways to finance of projects at the corporate level: equity and debt. When a company does not have capital to develop its projects it can issue stocks or take loans in capital markets. The company's assets are used as collateral for corporate debts. In case of default, the lenders can take the assets given as collateral in order to recover the totality or part of their investments.

One of the main differences between Project Finance and Corporate Finance relates to collateral. Unlike Corporate Finance, where all assets are collateral, in the Project Finance rights related to project cash flows and project assets are accepted as the main collaterals. Project Finance debts are usually *non-recourse* debts, that is, banks have no rights to assets belonging to the project owners in case of default. When the SPC debts are non-recourse debts, project risks do does not

interfere in the company's risk as far as credit rating is concerned.

Many contracts between parties involved in the project need to be made in order to make the Project Finance feasible. A Special Purpose Company (SPC), that is a legal entity external to the sponsor (the company that has the main interest in the project), must be constituted. Project participants, such as clients and suppliers, frequently play a role as stockholders in the SPC. Figure 1 illustrates the difference between the structures of corporate finance and project finance.

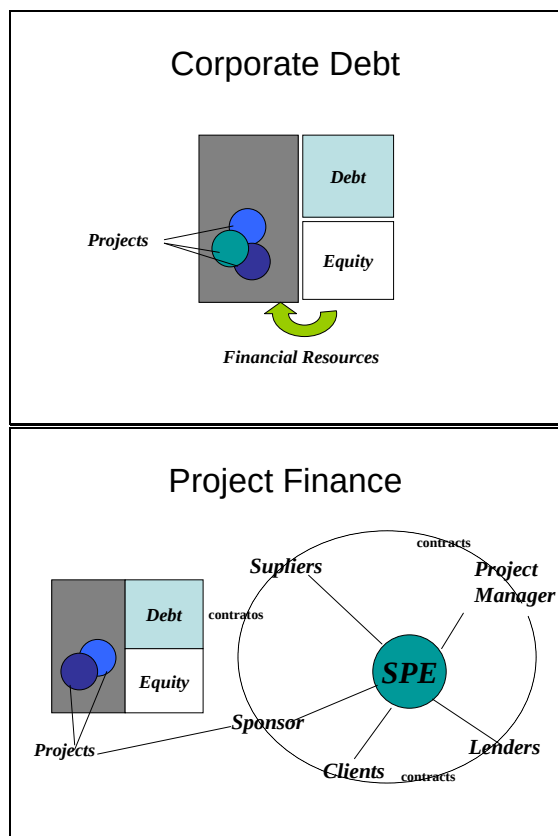


Figure 1: Difference between structures of corporate and project finance. Source: Prepared by the Authors.

An important issue for Project Finance feasibility is the projects financial design. As project cash flows are one of the main collaterals, the project must be designed in a way that cash flows are predictable, otherwise lenders will not accept to grant non-recourse financing. This is one of the main reasons why Project Financing is frequently used in infrastructure projects – such as electrical energy, telecom, toll roads, etc – for which it is possible to estimate cash flows with certain accuracy. The main issue of Project Finance is risk mitigation achieved mostly through contracts parties involved in the project. The goal here is to reduce project cash flows variability. Financial engineering is used to reduce risk while maintaining an attractive project rate of return,

thereby achieving both lenders' and SPC partners' objectives.

The Several Parties Involved in a Project Finance

A Project can have a wide variety of participants. The main ones are listed below:

- **Sponsor** – It is the company that is trying to make the project possible by assembling the Project Finance structure. An oil company using Project Finance to assemble an oil field project is a good example of sponsor.
- **Lenders** – They could be banks, governments, leasing companies, multilateral development agencies, or even – sometimes – suppliers or clients that have direct interest in the Project. Independently of other interests, the lenders always try to obtain an adequate remuneration of his resources, i.e.: a risk-return relation that justifies the loan.
- **Suppliers** – The suppliers of the main inputs for project may participate in the Project to guarantee demand for their products and make partnerships with their strategic clients. Commonly, suppliers sign contracts obliging them to provide inputs with predetermined prices in order to mitigate the project's risk.
- **Clients** – Some important clients can participate in a Project Finance. It generally happens when the output of the project is an important input to a clients' business. It is common that clients sign long term contracts obliging them to by products under predetermined conditions in order to mitigate project risks.
- **Managers** – Some companies – sometimes engineering companies or investment banks – which have the role of coordinating the project.
- **Governments** – When the national strategic interests are involved, governmental participation in Project Finance as lender or partner of the project is common.
- **Law Firms** – Considering the large number of contracts involved in Project Finance assembly, Law Firms are a very important party to a Project Finance.

Sources of Funding

A Project Finance can have one or many sources of funding. Some of the main kinds of funding used in Project Finance assembly are presented as follows:

- **Senior Debt** – They are loans given by banks or other lenders which – in case of default or bankruptcy – have priority in relation over other loans.
- **Subordinated Debt** – They are loans usually given by sponsors which are subordinated to senior debts. Convertible corporate bonds and corporate bonds

with performance fee are examples of subordinated debts. These loans usually, but not necessarily, pay higher rates of return than senior debts (SD). They may also have some additional benefits to SD, for example a stock option.

- Junior Debt – These loans are characterized for having higher rates of return and, many times, other advantages such as convertibility in stocks. In general these loans are given by financial institutions.
- High Risk Bond (Junk Bonds) – They are the last loans to receive in case of project bankruptcy and generally pay big spreads comparing to the other loans.
- Suppliers Credit e Tied Credits – They are credits given by equipment and raw material suppliers. Many multilateral development agencies give credits to finance the purchase of raw materials, products and equipment produced by national suppliers.
- Leasing – The lease of the equipment is one of the most common and important kind of funding to Project Finance.
- Sweat Capital – It is a common contract whereby suppliers of services or equipment accept that if costs exceed a certain threshold, the excess cost should be invested as capital in the enterprise.
- Development Banks and Multilateral Development Agencies – The support of these agencies can be fundamental to private sector's interest in a project. Many times the presence of Multilateral Development Agencies enables lower interest rates, because as privileged creditors, they have a default risk reduction.

Legal Structure

As it was said earlier, Project Finance implementation is usually related to the establishment of a Special Purpose Company (SPC). In addition to the SPC many contracts are generated. The main contracts involved in Project Finance are:

- Project Contracts – Contracts for construction, operation, maintenance and supply of raw material for the project.
- Insurance Contracts – Insurance contracts to ensure the project construction and project assets.
- Escrow Account – Centralizing bank account in whereto all project revenues are directed.
- Financing Contracts – Contracts made between SPC and Senior Lender in which there is usually a clause for additional collateral during construction phase. When there are many lenders there must be a collateral sharing agreement between them.
- Long Term Contracts for the Supply of Raw Material – Contracts made between SPC and the main suppliers of Project Finance in order to

guarantee the supply of raw materials as well as to define prices and quantities required by the project.

- Shareholders Agreement and other documents regarding partners' rights and obligations – These contracts define several shareholders' obligations and rights such as the partners' investment commitment, sponsors' responsibilities, dividend policy, among others.
- "Off-Take" Contracts – They are long term contracts of guaranteed supply that can be used as collateral for loans.

Project Finance versus Corporate Finance

There are many distinctive features in Project Finance compared to Corporate Finance and they should be analyzed in order to be understood which structure is better for each project.

As it was written earlier, one of the main distinctions between these two financing models is the fact that a Project Finance is structured to have little impact on the sponsor's credit risk. This does not mean that lenders will give out collaterals in a Project Finance, but that these collaterals will be structured in a way that have little effect on the sponsor's credit risk. Typically if the project is well structured, it will be able to issue non-recourse debt, which has little impact in the sponsors' credit rating

While in Corporate Finance banks analyze the general payment capacity of a company, in Project Finance they analyze cash flows and assets of the project separately from the sponsor's activities. This implies that SPC and the sponsor may have a different credit ratings.

In Corporate Finance the lenders do not interfere in corporate management and can, at best, oblige the company to follow some rules of stated financing contract (financial covenants, for instance). On the other hand, in Project Finance creditors make a routine check of the project's financial performance and project managers have little room to manage the project's money.

Lenders in Corporate Finance have a wide range of company's resources as collateral, which implies the diversification of risk in the portfolio of the company's assets. In the Project Finance lenders have little or no access to sponsor's funds or resources. The risk exposure of lenders is protected by the project structure and by contracts between the project's participants. Project risks are allocated to the participants that are better equipped and willing to accept them.

Comparatively Corporate Finance is structured quickly whereas Project Financing uses to be very time consuming. In Corporate Finance, investments in new projects can be financed, at least partially, by cash flows generated for other pre-existent projects. The assembly of Project Finance is considerably more expensive and slower than Corporate Finance and sponsors often have little flexibility in SPC capital allocation.

Project Finance does not increase the sponsor's default probability. Despite Project Finance contractual terms

being usually very restrictive, they are restricted to the project level. A portfolio of projects financed using non-recourse Project Finance may increase the overall corporate leverage as a steady flow of project dividends to the parent company may enable it to issue new corporate debt.

Risk Mitigation

The focal point of a Project Finance is the analysis and the distribution of the risks among the project participants. Risk changes over time, being larger during construction phase and smaller when the project is operational. In the initial phase of the project, when investments are generally made in the construction, project cash flows are negative. At this phase the sponsors may take corporate loans (frequently bridge-loans) while the long term, non-recourse loan is being structured. As the project begins to generate positive cash flows or when most risks have been reduced, corporate loans are changed to non-recourse, long term, Project Finance loans.

Each participant in a Project Finance must understand the risks that are being assumed and, furthermore, whether these risks can really be assimilated. Engineering Companies should consider if they are able to guarantee that building on time and if they can assimilate fines for delays. Suppliers, for example, should evaluate if they are able to ensure fixed prices or price caps for their products, while clients should evaluate if they are able to purchase raw materials or products with fixed prices or floor prices. Sponsors should consider whether they have sufficient experience to manage the project or whether it is better to hire another company to operate the project. Several risks may also be reduced or extirpated by instruments such as insurance contracts or derivatives in financial market.

Characteristics of Projects Funded By Project Finance

What are the main characteristics of projects funded by Project Finance? With the intention to answer this question Esty (2003) presents a research done with collected data from 1997 to 2001 in the international market. This research reveals that in these five years were invested US\$ 601.2 billion in projects with average value of US\$ 504 million, being 12% of the projects with investments over US\$ 1 billion. Approximately 85% of the projects came from the industries: electric, telecom, transport, oil & gas and petrochemical. The average initial financial leverage (debt/total capital) was 70% and construction time was 2 years on average. The average duration of sale contracts was approximately 20 years, and only 13% of this amount had a maturity over 25 years. The average concessions time was 28 years and approximately 14% of concessions had a maturity over 30 years.

A CASE STUDY OF ABENGOA

History and Activities

Abengoa was founded in the 1940's in Seville as a small engineering company specialized in electric assembly projects. The company grew in the Spanish market and, from the 1970's it started to diversify its activities internationally. But it was only from the 1990's on that the company started to invest in infrastructure assets, both in Spain and abroad.

Today Abengoa is a diversified group that focuses on three activities.

Engineering and construction

Engineering and Construction includes the traditional engineering activity in the energy, water and information technology sectors, in which Abengoa has more than 70 years of experience in the market. The company's specialization is carrying out complex turn-key projects for solar-thermal plants, solar-gas hybrid plants, conventional generation plants, transmission lines, water infrastructures (such as large-scale desalination plants), biofuel plants and critical control systems for infrastructures, among others.

Concession-type infrastructures

It consists of an extensive and young portfolio of proprietary concession assets that generate revenues that are governed by long term sales agreements with formats such as take-or-pay contracts, tariff contracts or power purchase agreements (PPAs). This activity includes the operation of solar plants, transmission lines, co-generation plants and desalination plants. These assets generate no demand risk and Abengoa's focus is operating them as efficiently as possible.

Industrial production

This activity incorporates some businesses with commodity risk, such as biofuels or recycling steel dusts and salt slag. The company has an important leadership position in the geographical markets in which it operates, with proprietary assets. (Source Abengoa web site: Our Company)

Abengoa's Corporate Structure

Figure 2 shows Abengoa Corporate Structure. Befesa and Abeinsa are heavy engineering companies and Telvent is the IT Company. Abengoa Solar, Befesa and Abeinsa all own concession-type infrastructures, while Abengoa Bioenergy and Befesa own industrial assets.

Abengoa is today a geographically diversified company. Figure 3 shows Revenues broken down by region, showing that 50% of Abengoa's revenues come from US, Brazil and Latin America.

As far as revenue is concerned, the most important activity is Engineering and Construction (E&C), accounting for 56% of total revenue (Figure 4)

Although concessions and infrastructure services account for only 6% of consolidated revenue, they are responsible for 22% of total EBITDA. Moreover, recurrent activities account for 56% of total EBITDA, while only 44% come from cyclic, Engineering and construction businesses.

Abengoa's Strategy

Abengoa's current investment strategy focuses on new concession-type project assets, built by Abengoa's Engineering companies. Abengoa is already committed to new projects that will multiply by 5 its solar assets, double its transmission assets and more than double its desalination assets as shown in Figure 6.

Abengoa fully explores all the synergies between construction activities and infrastructure services. Figure 7 shows part of this strategy. Abengoa's Financial strategy involves access to long term, corporate debt at the Abengoa companies level (Abengoa issues debt mostly through the holding company, but other operational companies may also issue corporate debt). Abengoa parent companies receive cash-flows from project companies both through dividends, through construction contracts and through O&M contracts with parent companies. Infrastructure project companies also issue long term debt, but this debt is non-recourse, project financing debt. Project financing is an important part of the strategy as banks that lend long-term resources to Abengoa parent companies do not consider non-resource debt as part of Abengoa's net debt.

Abengoa's Evaluation Model

When Abengoa evaluates a new project the synergies between parent companies and project companies are fully taken into account. Figure 8 shows a Solar Plant Project simplified cash-flow. Besides dividends, construction and O&M cash-flows for parent companies are taken into account. Non-recourse debt cash flows are treated with the project cash flow and corporate interest payments are also reckoned with.

A rough estimation of the gains obtained through this vertical integration, high leveraged strategy in Solar Plant Project was made from the example above. The solar project itself (Financial Investments and Project Cash Flows) will yield a 9% Internal Return Rate (IRR). When all the cash flows are fully accounted for, the consolidated IRR raises to 12,6%.

Abengoa's Economical and Financial Performance

In this section, it is presented an analysis of the last ten years of Abengoa's financial statements, in order to

assess the effect of its strategy in its economical and financial performance.

As it can be seen in Table 1 and Figure 9, Abengoa's Net Turnover and EBITDA have been increasing substantially since 2001, respectively by 16.8% and 21.2% of CAGR, which made its EBITDA Margin change from 9.2% in 2001 to 11.2% in 2010.

On the other hand, as it can be seen in Table 2 and Figure 10, as the Total Assets of Abengoa has been growing by 26.1% of CAGR, the Asset Turnover ratio has been decreasing in the same period, which made Abengoa's ROA also decrease from 7.93% in 2001 to 5.55% in 2010.

Most of this huge increase in assets has been financed by new debt – corporate debt and project financing – taken by Abengoa, which made its D/E ratio change from 1.9 to 5.7 in the last decade. Table 3 and Figure 11 show the evolution of Abengoa's capital structure composition in the period of 2001 to 2010.

Abengoa's higher leverage has not hindered its access to debt markets. Actually, banks do not perceive an increase in total debt as an increase in corporate risk, since a large part of total debt consists in project financing. Abengoa's long term corporate debt has only one covenant: Net Corporate Debt/Corporate EBITDA. Cash, debts and EBITDA in projects financed by non-recourse debt are not taken into account. Only corporate cash, corporate debt, corporate EBITDA (including project dividends) are considered for its 3.0 Net Corporate Debt/Corporate EBITDA covenant. By this standard, Abengoa still has room for new corporate debt as Net Corporate Debt/Corporate EBITDA has ranged from 1.17 to 1.84 from 2007 to 2009.

However, as a consequence of the greater total financial leverage Abengoa's ROE has substantially increased, even considering the increase in its interest expenses. On the other hand, higher leverage also brought a higher beta and consequently Abengoa's cost of equity also increased in the same period, as it can be seen in Table 4 and Figure 12.

However, taking into consideration the rise in value created for Abengoa's stockholders in the last ten years, the final economical result of Abengoa's financial strategy has been extremely positive. As it can be seen in Table 5 and Figure 13, Abengoa's EVA had a substantial growth from 2001 to 2010, which largely explains the performance of Abengoa's stock in the period.

Finally, Table 6 and figure 14 point out another interesting effect of Abengoa's strategy, the huge financial cycle reduction from 2.4 days to -164.8 days between 2001 and 2010, which consequently implied in an increase of cash position caused by working capital reduction.

CONCLUSIONS AND FURTHER RESEARCH

Abengoa successfully evolved from business strategy focused on heavy engineering to include both

construction activities and long term investments in infrastructure assets. Abengoa fully explores all aspects of the synergy between construction business and infrastructure services:

- i. As a substantial part of Abengoa's corporate cash flows come from non-cyclic infrastructure projects dividends, Abengoa has access to long-term corporate debt at the holding company level.
- ii. Long term debts and corporate cash flows that are ultimately derived from infrastructure projects (project construction cash flows, project O&M cash flows and project dividends) are used to finance equity in new projects that, in their turn, issue non-recourse project finance debts to help fund construction of infrastructure assets. As new projects generate new construction, O&M and dividends, they increase the holding company's ability to issue more long term debt.
- iii. Construction budgets are managed to produce payables with long maturities. As a consequence, working capital is a source of cash in Abengoa's financial model.

This financial model has led to a highly leveraged capital structure. Nonetheless, Abengoa has managed to properly allocate risk in order to preserve access to debt markets. Credit risk is mitigated because a large part of Abengoa's consolidated debt consists in non-recourse project financing. Working capital is also used as a source of long-term resources. As neither non-recourse debt and working capital are considered in Abengoa's main corporate debt covenant (net corporate debt/net corporate EBITDA), Abengoa's highly leveraged capital structure is not an object to raising new debts the corporate level to finance equity investments in new projects.

Abengoa has an ambitious investment plan. Abengoa will more than triple its Solar and desalination assets by 2013-14. By that date, Abengoa will have almost

doubled its cogeneration assets it will have more than doubled its transmission assets.

As every highly leveraged company, Abengoa needs strict financial discipline to successfully fulfill its investment plan. Abengoa only commits to a new investment project when financing is secured both at the project and at the holding company level. This is the main reason why Abengoa consistently accumulates large volumes of cash. As of December 2010 Abengoa had roughly € 3 billion in cash.

Abengoa's track record in from 2001 to 2010 is an outstanding one. Rapid growth was achieved mostly through investing in fixed assets, a large part of which are infrastructure assets. Abengoa's highly leveraged financial strategy leads to very competitive pricing in public auctions for infrastructure assets as one can infer from Abengoa's low Return on Assets (ROA), ranging from 4% to 6% from 2006 to 2010. Were not Abengoa a highly leveraged company a low ROA would translate in a low Return on Equity (ROE). But through leverage, achieves ROE from 17% to 26% in the same period. As a result, Abengoa created value for the stockholder during the whole period analyzed here: the company boasts a positive Economic Value Added (EVA) in every single year from 2001 to 2010.

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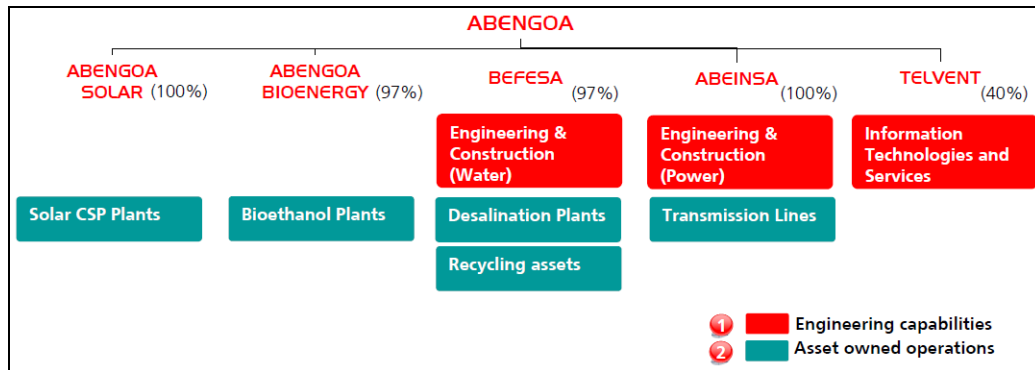


Figure 2: Abengoa Corporate Structure. Source: Abengoa's Credit Update 2010.



Figure 3: 2010 Revenue breakdown by region. Source: Abengoa's 2010 Earnings Presentation

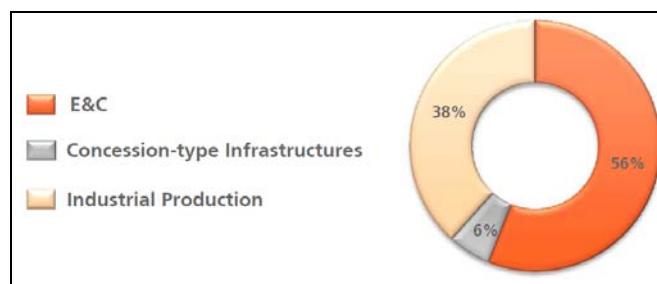


Figure 4: Abengoa 2010 Revenue breakdown by activity. Source: Abengoa's 2010 Earnings Presentation

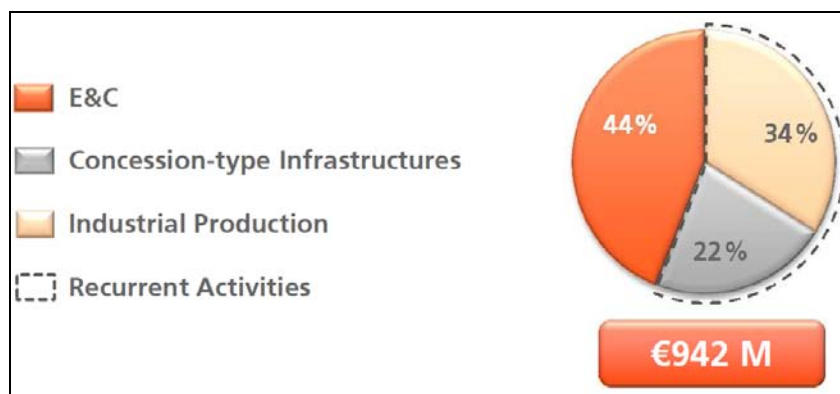


Figure 5: Abengoa's 2010 EBITDA breakdown by activity. Source: Abengoa's 2010 Earnings Presentation

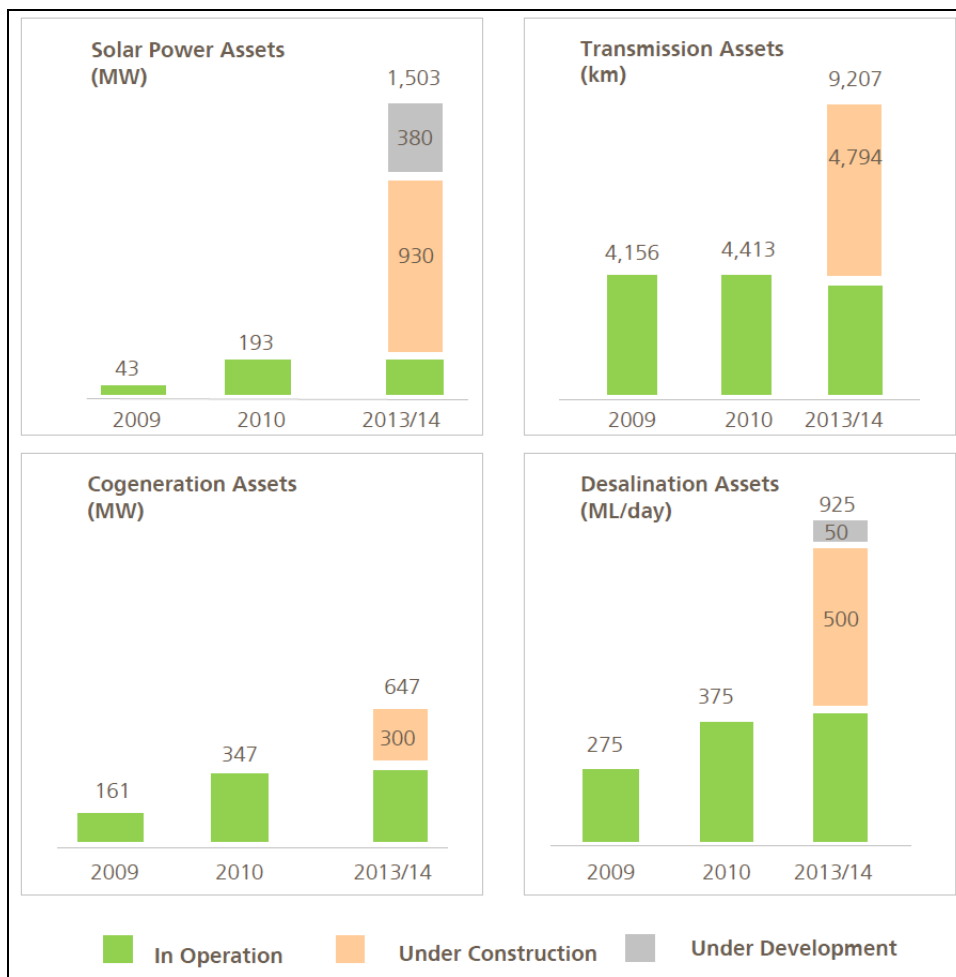


Figure 6: Abengoa's Assets. Source: Abengoa's 2010 Annual Report

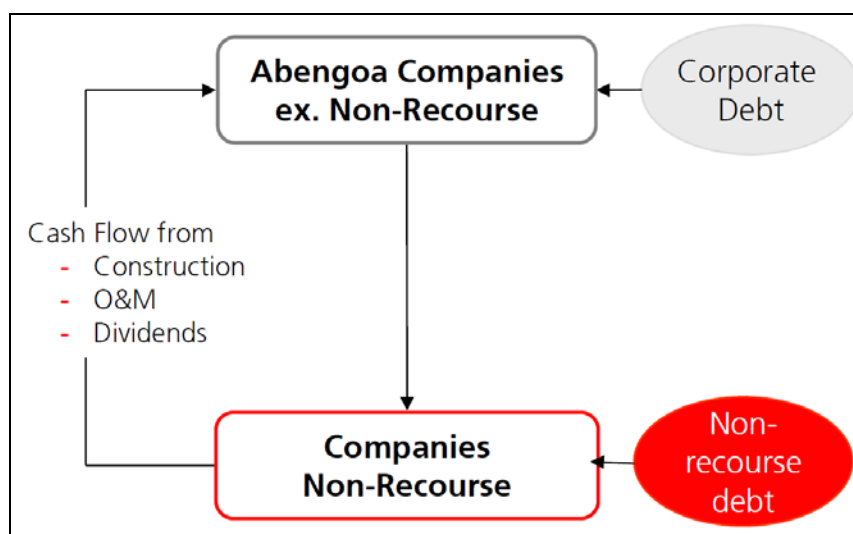


Figure 7: Abengoa's Financial Strategy. Source: Abengoa's 2010 Credit Update 2010.

EUR in millions		year	-1	-2	1	2	3	4	5	6 - 34
Construction Business										
a	FCF from construction, development, equipment, technology fees...	20	20							
Corporate & Operational Business										
b	FCF from Management Fees and O&M Margins				1	1	1,25	1,3	1,3	47
Financial Investment										
	Capital Expenditure	125	125							
c	Abengoa equity funding	-44	-44							
Project Cash-Flows										
1	FCF before debt Service				26	26	26	26	26	790
2	Project Finance Net Interest				-11	-11	-11	-11	-11	-107
3	Project Finance debt drawdown/(amortisation)	81	81		-3	-3	-3	-4	-5	-144
1 + 2 + 3	Excess cash-flow for Shareholders				12	12	12	11	10	539
a - c	d Net cash-flow for Abengoa pre-operation	-24	-24							
e	Cash-flow for Abengoa post-construction (dividends + b)				9	9	9	9	9	597
f	Net Corporate Interest exp. after taxes	-1	-3		-3	-3	-3	-3	-3	-81
d + e + f	Net cash-flow for Abengoa	-26	-27		6	6	6	6	6	516

Assumptions :

- 250 M€ investment cost
- 65% non-recourse debt @ project level
- 100 GWh net annual production of electricity
- Pool price + Premium = 330 €/Mwh

Figure 8: Solar Plant Project Simplified Cash Flow. Source: Abengoa's Credit Update 2010.

Table 1: Abengoa's Net Turnover, EBITDA, Interest and Profits.
Source: Abengoa's Financial Statements 2001 to 2010

in Million	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Net Turnover	1,379.9	1,521.4	1,635.3	1,746.1	2,023.5	2,677.2	3,214.5	3,769.2	4,147.3	5,566.0
EBITDA	166.5	174.7	185.2	183.8	221.7	295.4	322.9	459.3	750.0	942.0
Interests	79.9	99.5	76.6	78.3	58.8	91.9	140.5	293.9	181.4	368.4
Profits	41.5	43.5	47.0	52.4	66.0	100.3	120.4	140.4	170.3	207.0

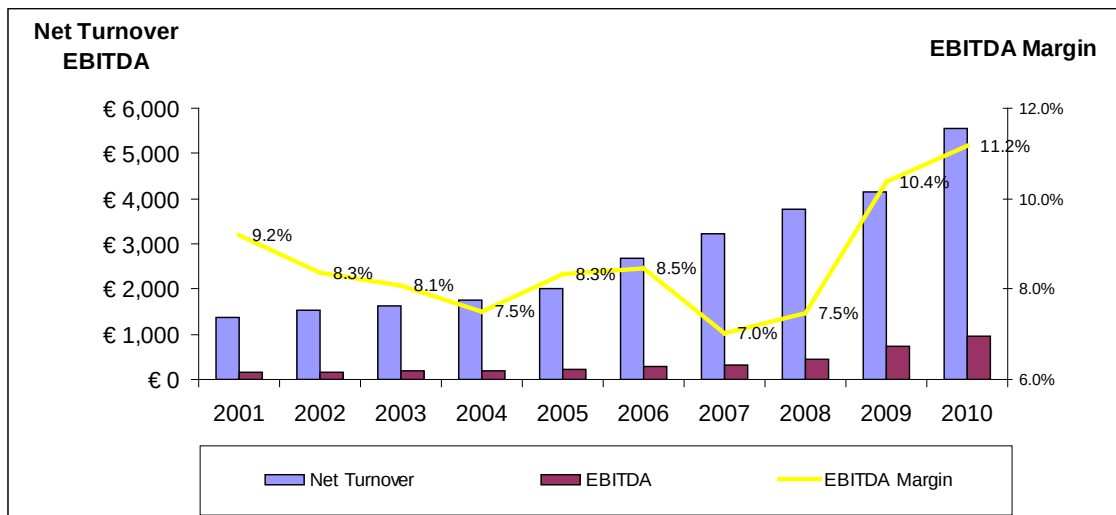


Figure 9: Abengoa's Net Turnover, EBITDA, EBITDA Margin. Source: Abengoa's Financial Statements 2001 to 2010

Table 2: Abengoa's Assets Turnover, EBITDA Margin and ROA. Source: Abengoa's
Financial Statements 2001 to 2010

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Assets Turnover	66%	66%	69%	70%	61%	49%	40%	38%	34%	33%
EBITDA Margin	9.19%	8.35%	8.06%	7.50%	8.34%	8.47%	7.01%	7.45%	10.38%	11.16%
ROA	7.93%	7.56%	7.84%	7.38%	6.67%	5.44%	3.98%	4.69%	6.06%	5.55%

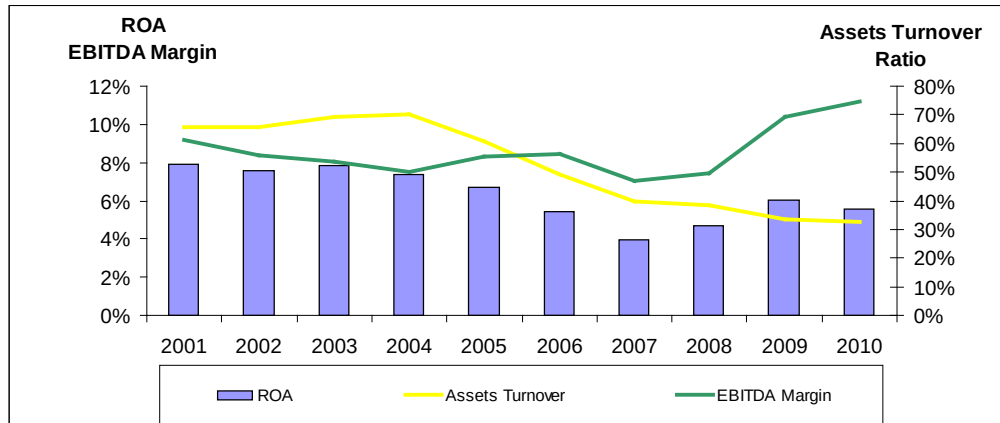


Figure 10: Abengoa's ROA, Assets Turnover and EBITDA Margin.
Source: Abengoa's Financial Statements 2001 to 2010

Table 3: Abengoa's Capital Structure. Source: Abengoa's Financial Statements 2001 to 2010

in ☐ Million	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Total Debt	696.6	881.0	877.8	1,108.2	1,561.0	2,790.2	4,538.8	4,780.7	6,415.5	9,211.7
Corporate Debt	495.0	611.1	608.1	743.4	890.1	1,536.4	2,849.7	2,688.0	3,482.1	5,161.6
Project Finance	201.6	269.9	269.7	364.8	670.8	1,253.9	1,689.2	2,092.7	2,933.4	4,050.1
Equity	363.1	351.6	377.9	522.2	526.2	541.1	797.5	627.5	1,171.0	1,630.3
Debt/Equity Ratio	1.9	2.5	2.3	2.1	3.0	5.2	5.7	7.6	5.5	5.7

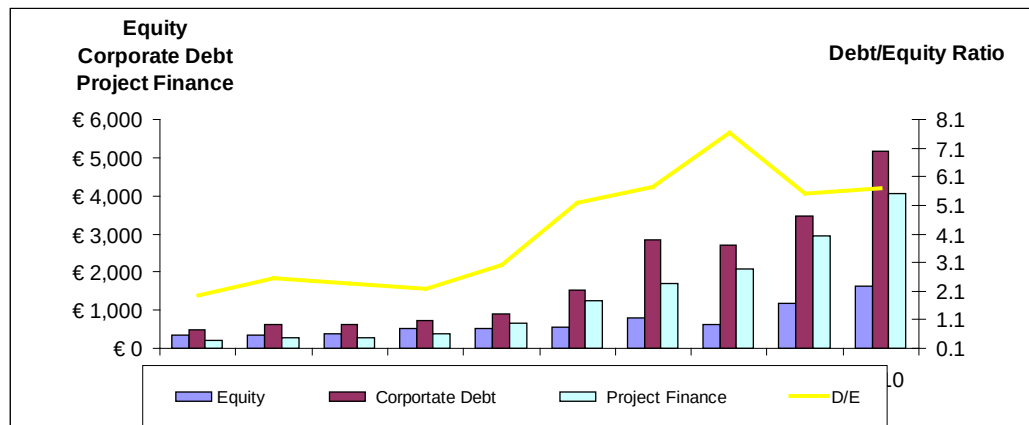


Figure 11: Abengoa's Capital Structure. Source: Abengoa's Financial Statements 2001 to 2010

Table 4: Abengoa's Cost of Capital. Source: Abengoa's Financial Statements 2001 to 2010

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Debt/Equity Ratio	1.9	2.5	2.3	2.1	3.0	5.2	5.7	7.6	5.5	5.7
Beta	0.30	0.33	0.52	0.71	0.85	1.55	1.22	1.05	1.20	1.60
Ke real	5.4%	5.2%	5.4%	5.9%	6.1%	9.7%	8.1%	5.7%	7.2%	9.6%

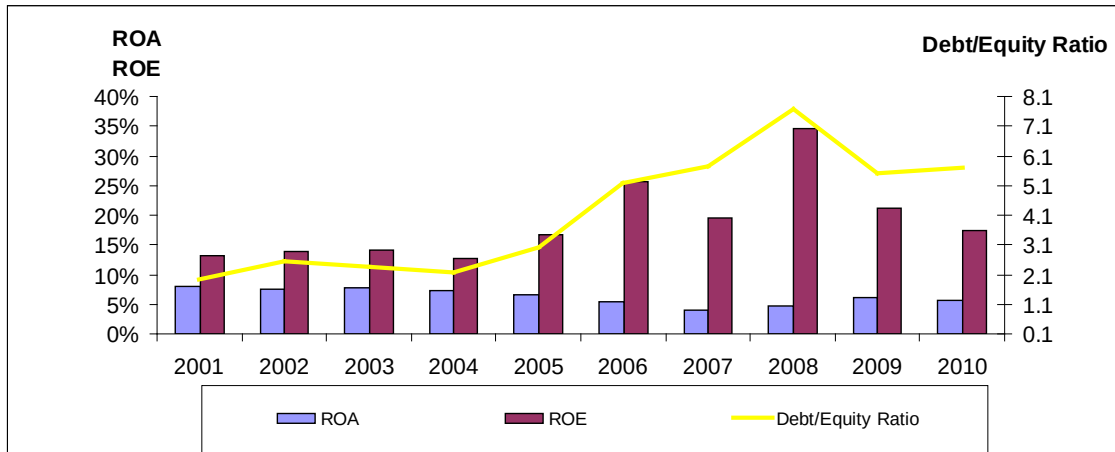


Figure 12: Economic Performance and Financial Leverage. Source: Prepared by the Authors.

Table 5: Abengoa's Economic and Stock Price Performance.
Source: Abengoa's Financial Statements 2001 to 2010. Prepared by the Authors.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
ROE	13.1%	14.0%	14.2%	12.7%	16.7%	25.7%	19.5%	34.5%	21.2%	17.4%
Ke real	5.4%	5.2%	5.4%	5.9%	6.1%	9.7%	8.1%	5.7%	7.2%	9.6%
EVA (in □Million)	24.3	27.4	29.2	27.9	41.9	62.4	70.6	117.3	112.3	92.8
Stocks (in □)	7.7	6.9	5.1	7.1	10.7	21.6	29.1	17.7	16.2	18.5

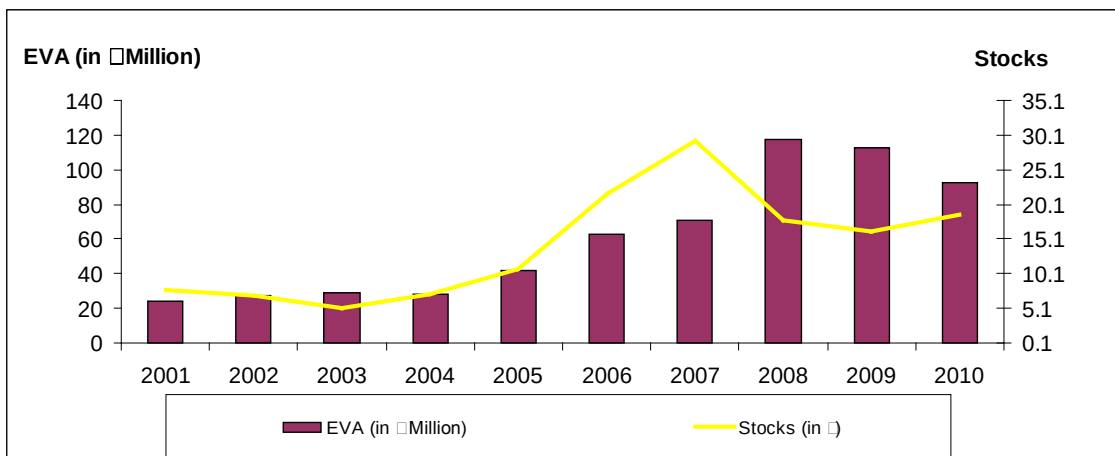


Figure 13: Abengoa's Economic and Stock Price Performance.
Source: Abengoa's Financial Statements 2001 to 2010. Prepared by the Authors.

Table 6: Abengoa's Financial Cycle, Working Capital and Cash.
Source: Abengoa's Financial Statements 2001 to 2010. Prepared by the Authors.

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Fin.Cycle (days)	2.4	(9.7)	(20.0)	(17.4)	(34.6)	(43.5)	(91.3)	(133.0)	(149.3)	(164.8)
Work.Capital	9	(41)	(91)	(84)	(195)	(323)	(815)	(1,392)	(1,720)	(2,547)
Cash	320	376	426	357	567	1,136	1,698	1,334	1,546	2,983

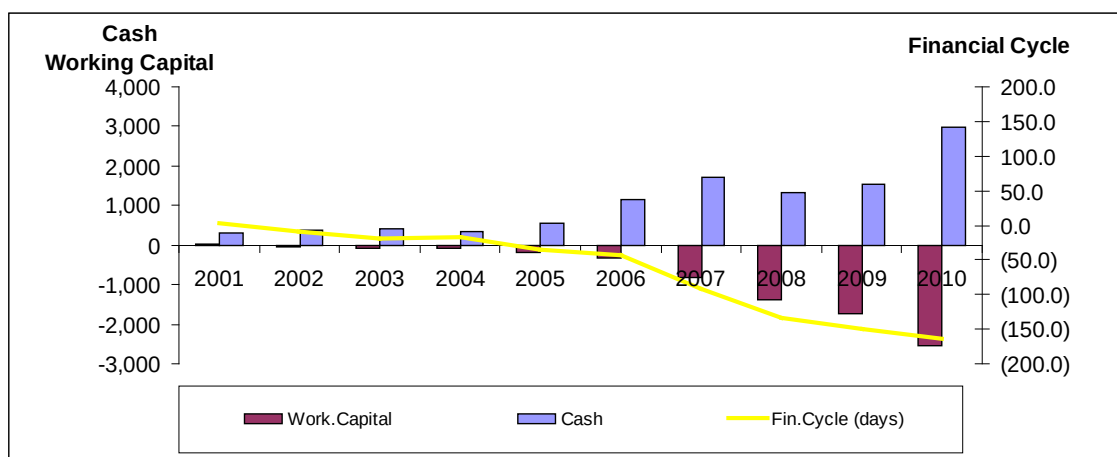


Figure 14: Abengoa's Financial Cycle, Working Capital and Cash.
Source: Abengoa's Financial Statements 2001 to 2010. Prepared by the Authors.

REAL OPTIONS THEORY IN COMPARISON TO OTHER PROJECT EVALUATION TECHNIQUES

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KEYWORDS

Real Options, Discounted Cash Flow Techniques,
Project Evaluation

ABSTRACT

Wrong investment decisions today can lead to situations in the future that will be unsustainable and lead eventually to the bankruptcy of enterprises. Therefore, good financial management combined with good capital investment decision-making are critical to survival and long-term success of the firms. Traditionally, the net present value (NPV) and discounted cash flow (DCF) methods are worldwide used to evaluate project investments. These techniques have been classified in two major groups: sophisticated and non-sophisticated. In the former group, techniques like the DCF methods (e.g. NPV and IRR) can be found. In the latter group, techniques like the Payback Period and the Accounting Rate of Return have been included. However given that, today investments are characterized by high risks and uncertainty, DCF methodologies are inadequate to deal with these issues. Some authors argue that only the techniques that can appropriately address the problem of uncertainty (like the Real Options theory) should be applied. In this paper, the major differences between DCF methods and Real Options (RO) theory will be analyzed. Using an example, the advantages of the RO theory, compared with other methods, such as the DCF methods, in the search of better decisions will be shown. This work is expected to contribute to an increase of application of the RO Theory, by showing this technique potential.

INTRODUCTION

Investment decisions are extremely important, both from the point of view of the economic development and the business perspective. Today's global crisis only reinforces this idea. (Bennouna et al., 2010) The competitiveness of enterprises is a key factor for its success. Thus, correct investment decisions by firms are, among other aspects, essential to accomplish that objective. In this regard, the investment appraisal techniques used by firms is a question of paramount importance. Accordingly, the techniques used in the analysis of investments should provide relevant and

quality information, so that the uncertainties of the future start to be present certainties. In order to avoid bad (or wrong) decisions, the academic community has, over the years, developed more accurate techniques for investment evaluation. These techniques have been classified in two major groups: sophisticated and non-sophisticated. In the former group, techniques like the Discounted Cash Flow (DCF) methods (e.g. NPV and IRR) can be found. In the latter group, techniques like the Payback Period and the Accounting Rate of Return have been included. However, several studies (Graham and Harvey, 2002, Ryan and Ryan, 2002) indicate a tendency for an increasing number of companies to use those more sophisticated methods for evaluation of investment projects. With the increase of the economic and financial uncertainty, some authors (Dixit and Pindyck, 1994, Smit and Trigeorgis, 2004, Verbeeten, 2006) claim that even those sophisticated techniques may not be as accurate as it would be necessary. They argue that only the techniques that can appropriately address the problem of uncertainty (like the RO Approach) should be applied. Those techniques (DCF) make implicit assumptions, like the reversibility of investments. In other words, an investment can be undone and the expenditures recovered. On the other hand, if a firm does not undertake the investment now, it will not be able to do it in the future and this will become unrecoverable (Amram and Kulatilaka, 1999). In fact, most investment decisions share three important characteristics (Dixit and Pindyck, 1994): a) the investment is partially or totally irreversible (i.e. the initial capital expenditure is at least partly a sunk cost); b) there is uncertainty about the investment return (i.e. the best one can do is to assign probabilities to different possible outcomes); and c) the promoter of the investment has some freedom to decide the most appropriate time to make the investment (i.e. the investment decision can be postponed in order to obtain more information about the future and thus reduce the uncertainty). These three characteristics interact to determine the optimal decision of investors. In fact, the ability to delay an investment, in order to obtain more information and thus reducing uncertainty, provides management with a valuable opportunity to modify both investment and the strategy to follow, in order to get better future opportunities or to reduce future losses. Thereby, this possibility can be seen as an option due to the fact that a company has the opportunity to

invest, or simply not investing, similar to a financial call option (Dixit and Pindyck, 1994). From this premise, the capital budgeting can be treated in the field of RO, term that was firstly used by Myers (1997). Unlike DCF methods, the RO theory centers on the valuation of the managerial flexibility to answer to different scenarios with high levels of uncertainty. This theory is known as a modern approach for economic valuation of projects under uncertainty (Marreco and Carpio, 2006). The concept of RO arose from financial options. Its foundations lay in the Nobel Prize awarded work on the pricing of financial option contracts, developed by Fisher Black, Robert Merton and Myron Scholes. The option-pricing theory had applications for all kind of investments, whether they are financial or nonfinancial (Black and Scholes, 1973). From the first application until today, RO theory has been applied in almost all sectors, from energy sector to R&D investments (Lee and Shih, 2010, Block, 2007, Benninga and Tolkowsky, 2002, Laurikka and Koljonen, 2006). In the energy sector, RO proved that can evaluate better than DCF methods (Martínez-Ceseña and Mutale, 2011, Yang and Blyth, 2007). Same conclusions can be drawn to the natural resource extraction industries (Siegel et al., 1987, Paddock et al., 1988, Fan and Zhu, 2010). Those studies show the wide range of applicability and prove that RO theory can give better quality information to the decision makers than other project evaluation techniques (Luehrman, 1998). The remainder of this paper is organized as follows. Section 2 gives an introduction to the theoretical background of the real options theory. Section 3 presents an application example of the real options theory. Section 4 concludes the paper presenting the main findings and some perspectives for further research.

REAL OPTIONS THEORETICAL BACKGROUND

To better understand the RO reasoning/approach, it is important to provide a brief glance over the financial options. To start with it is necessary to distinguish between a call option and a put option. A call option is a contract that gives the buyer the right, but not the obligation, to buy something at a specified price in the future (and the seller of the call has the obligation to deliver the good or asset if the call owner exercises the option). A put option is a contract that gives the buyer the right, but not the obligation, to sell something at a specified price in the future (and the seller of the put has the obligation to take delivery of the good or asset should the put owner decide to exercise his option). The something that can be bought (or sold) with the option is called the underlying asset. The specified price is called the exercise price and the future date is called the expiration date.

In the context of real options, one can define a RO “as the right, but not the obligation, to take an action (e.g.,

deferring, expanding, contracting or abandoning) at a predetermined cost, called exercise price, for a predetermined period of time – the life of the option” (Copeland and Antikarov, 2003). Therefore, an opportunity to invest is similar to a financial call option. If it is possible to find a call option like an investment opportunity, the value of that option would tell investors something about the value of the investment opportunity. So, it has to be established a relation between the investment project characteristics and the variables that are needed to value a call option, and this is shown in table 1.

Table 1: Analogy of the call option and the project characteristics

Project characteristics	Variable	Call option
Present value of expected cash flows		Stock price
Present value of investment outlays		Exercise price
Length of deferral time		Time to maturity
Time value of money		Risk-free rate
Volatility of project's returns	σ	Variance of stock returns

The value of a call option can be obtained using the Black-Scholes option pricing model, described in Equations 1, 2 and 3 (Black and Scholes, 1973)

(1)

Subject to,

$$\frac{\partial C}{\partial t} + rC - \frac{1}{2}\sigma^2 S^2 \frac{\partial^2 C}{\partial S^2} - (r - \delta)S \frac{\partial C}{\partial S} = 0 \quad (2)$$

$$C = 0 \quad (3)$$

As can be seen, most of the data that are needed to evaluate a project using the DCF methods is the same data that will be used in RO model.

Where DCF methods and Real Options are equal and where they are different

The DCF methods use net present value (NPV) to assess the value of an investment opportunity. Thus, NPV is no more than the difference between the project present value and the required capital expenditures, as shown in equation 4:

(4)

When this difference is positive, the investment project is accepted, otherwise is rejected. Curiously, the option value has the same value as the NPV when the project can no longer be deferred. For other words, when the

option has reached its expiration date (maturity time). Equation 5 shows that:

(5)

When NPV is negative, the company does not undertake the project, so the project value is effectively zero, rather than negative. This happens because of the fact that at $t=0$, σ and ρ do not affect the call option value.

These techniques differ when the decision to invest can be deferred. In this case, two sources of value arise. Firstly, it is always preferable pay later than sooner, all else being equal, because it can be earned the time value of money. By investing later, it can be earned the interest on the capital expenditures. That value is the discounted present value of the capital expenditures. In other words, is the present value of the exercise price. Secondly, deferring the decision will turn the uncertainties of the future into certainties of the present. These uncertainties can be measured by assessing probabilities of the future possible project returns. This means that the variance of the project returns will be the percentage gained or lost per year. So, a project return with high variance is riskier than a project with lower variance. Thus, their returns will be either much higher or much lower than average. These new sources of value are the “heart” of RO.

EXAMPLE: VALUING A CHEMICAL INDUSTRY

To show an application of the RO theory in comparison with de DCF methods, an example will be now presented. This case study was firstly used in the work of (Luehrman, 1998), with some differences to better illustrate the applicability of the RO and their major differences relatively to DCF methods.

The managers of a chemical industry proposed a phased expansion of their manufacturing facilities. They want to build a new plant immediately to exploit innovations in process technology. Then, they anticipate future investments. In three years, they intend to expand the plant's capacity. So, there are two investments, the first of 79.250.000,00 € and the second of 242.188.000,00 €. The other required information is presented in the tables 2 and 3. It can be seen that the NPV of the investment is almost zero. However the managers feel that this analysis is missing something.

In fact, this project can be regard as one that incorporates an option, because of the fact that the first phase of the investment buys the right to expand three years later.

Table 2: DCF calculation – Operating projections

Operating Projections	Years						
	0	1	2	3	4	5	6
1. Revenues		288,47	349,33	507,20	684,72	757,63	795,67
2. Cost of goods sold		216,38	263,05	377,86	514,24	566,73	596,78
3. Gross Profit (1-2)		72,09	86,29	129,34	170,48	190,90	198,89
4. SG&A expense		69,99	82,42	138,97	159,51	177,71	182,21
5. Operating Profit (3-4)		2,09	3,87	-9,64	10,97	13,19	16,67

The values are shown in M€.

Table 3: DCF calculation – Cash flow calculation

Cash flow calculation	Years						
	0	1	2	3	4	5	6
6. EBIT (1-taxrate)		1,39	2,58	-6,42	7,31	8,79	11,12
7. Depreciation		12,05	13,31	13,31	29,35	30,50	31,70
8. Capital Expenditures	63,40	5,14	6,02	194,64	10,14	10,33	10,78
9. Increase NWC	15,85	2,60	3,49	47,55	4,50	5,07	6,15
10. Cash Flow	-79,25	5,71	6,38	-235,30	22,02	23,88	25,89
11. Terminal value, assets (perpetuity value with 5% per year growth)							386,93
Discount factor (12%)	1,00	0,89	0,80	0,71	0,64	0,57	0,51
PV per year	-79,25	5,09	5,09	-167,48	13,99	13,55	209,15
NPV	0,14						

Values are shown in M€.

Real Options valuation

To start valuing the option, it is necessary to identify the options that are embedded in the project. Thus, the first investment gives the company the option to expand in three years. As has been said, this project can be seen in two phases, or as two different projects: phase 1 corresponds to the initial investment and phase 2

corresponds to the second investment. Tables 4, 5 and 6, summarize and evaluate these phases separately. As it can be seen, phase 1 has a positive NPV whereas phase 2 as a negative NPV. Therefore, any rational decision maker would accept phase 1 investment and reject the phase 2 investment. However, this decision would be wrong.

Table 4: DCF calculation separately phase 1

Phase 1	Years						
	0	1	2	3	4	5	6
1. Cash flow	0,00	5,71	6,38	6,89	7,38	8,47	8,96
2. Terminal value	0,00	0,00	0,00	0,00	0,00	0,00	121,09
3 Investment	-79,25	0,00	0,00	0,00	0,00	0,00	0,00
Discount factor (12%)	1,00	0,89	0,80	0,71	0,64	0,57	0,51
PV per year	-79,25	5,09	5,09	4,90	4,69	4,81	65,89
NPV	11,22	Values are shown in M€.					

Table 5: DCF calculation separately phase 2

Phase 2	Years						
	0	1	2	3	4	5	6
1. Cash flow	0,00	0,00	0,00	0,00	14,65	15,41	16,93
2. Terminal value	0,00	0,00	0,00	0,00	0,00	0,00	265,84
3 Investment	0,00	0,00	0,00	-242,19	0,00	0,00	0,00
Discount factor (12%)	1,00	0,89	0,80	0,71	0,64	0,57	0,51
PV				-172,38	9,31	8,74	143,26
NPV	-11,08	Values are shown in M€.					

Table 6: DCF calculation separately phases 1 and 2

Phase 1 & 2	Years						
	0	1	2	3	4	5	6
1. Cash flow	0,00	5,71	6,38	6,89	22,02	23,88	25,89
2. Terminal value	0,00	0,00	0,00	0,00	0,00	0,00	386,93
3 Investment	-79,25	0,00	0,00	-242,19	0,00	0,00	0,00
Discount factor (12%)	1,00	0,89	0,80	0,71	0,64	0,57	0,51
PV	-79,25	5,09	5,09	-167,48	13,99	13,55	209,15
NPV (total)	0,14	Values are shown in M€.					

In fact, phase 2 has a lot of potential, and with a small increase in variance of its returns this phase would have a positive NPV. By evaluating this phase with the traditional DCF methods, this variance is not taken into account.

As mentioned earlier, in the field of RO theory, this variance is called uncertainty.

Valuing this second phase as a growth option will provide some differences in their value. Table 7 shows the variables needed to evaluate this phase and table 8 shows the value of the option.

Table 7: Real Options input data

Real Options Input Data		
Variables	Project characteristics	Value
S	Present value of the phase 2 assets	161,31
X	Necessary investment in year 3 to obtain phase 2 assets	242,19
t	Length of time phase 2 spending can be deferred	3
r_f	Time value of money	12%
σ	Standard deviation per year on phase 2 assets	40%

Values are shown in M€.

Table 8: Option valuation

Black-Scholes Formula	
Phase 2 value	38,55 €
d1	-0,06698552
d2	-0,759805843
NPV (Phase 1 + option value of phase 2)	49,77 €

Values are shown in M€.

In the DCF methods the uncertainty is not directly incorporated in the calculations. In this example, a standard deviation of 40% was used, as proposed by Luehrman (1998). This author argues that 40% is an average value for investment projects with same risk as this. However, an analysis for different values of uncertainty was done, in order to illustrate the importance of this concept in the evaluation of projects.

Using the RO theory to evaluate phase 2 it is obtained a positive value, which could seem odd at first sight. Nevertheless, in that value is included the value of deferring the decision, and the possible variations on the returns of that phase. Figure 1 shows that even with a small variance, the phase 2 value would become positive.

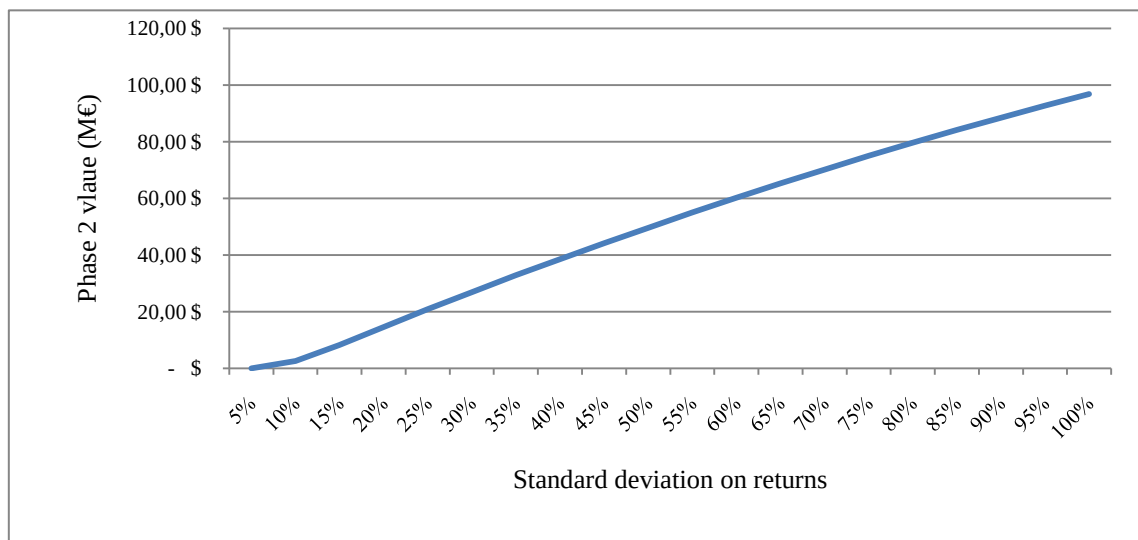


Figure 1: Phase 2 values for different standard deviation on return

A project with that variance is a project with a very little risk. So, if the decision was deferred for 3 years, the decision maker would know what happened three years later and would know what to decide. With the DCF methods the decision maker would reject the phase 2,

and lose a good investment opportunity in year 3. Evaluating this investment project using RO the NPV arose from a 0,1 to a 49,77 (M€). This new NPV value is more accurate than the old NPV, because of the fact

that it takes into account the deferring value and the uncertainty value.

CONCLUSIONS AND FURTHER RESEARCH

The traditional DCF methods fail in the evaluation of projects that are characterized by uncertainty and high financial risks. Those methods do not take into account the possibility of variations on cash-flows, according to market changes or sensitivity of investors. Those changes are extremely important. A project that seems good can be turned into a bad one, only by the uprising of the prices of raw materials, or a sudden crisis of the financial markets. The RO approach does not give the answer to all the issues in the project evaluation. However, it can provide more accurate information to the decision maker, giving the possibility of better decisions. Curiously, by incorporating risk in the analysis, this is done with less risk. In other words, the results obtained are more precise. Sometimes, DCF methods provide misleading information and that is the major drawback of those methods. On the other hand, RO theory is often difficult to apply in practice. In fact, uncertainties are extremely difficult to be obtained with precision and require sophisticated techniques, like simulation tools. Also, the equations that are used in RO require a great mathematical knowledge and can be arduous to apply. Even the line of thought that should be followed in order to use RO theory is different from the one that is needed in DCF methods. This rupture of thinking is as difficult as applying the methodology. Despite the great theoretical advantages of RO approach that were pointed out, to the author's best knowledge, this approach has not been much applied (or used in real situations). So, developing software that could turn RO more "user friendly" is an important step in. The training of managers in order to raise awareness of the potential of this approach is a great way to the spread of RO. This technique can be applied to almost all investment sectors. However, the absence of applications has been an obstacle to their use. For example, in the field of renewable energy sources, which is a sector with a high level of uncertainty, the development and application of RO can provide better knowledge of their correct value. Not only on energy sector, but also in major public investments, like airports, seaports or railways, RO can be an important tool to better evaluate (or assess) the value of investments.

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EVIDENCE ON THE INVESTMENT-CASH FLOW SENSITIVITY FOR A PANEL OF PORTUGUESE MANUFACTURING FIRMS

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KEYWORDS

Capital Investment, Financing constraints, Asymmetric information

ABSTRACT

In the last two decades, a renewed interest about the influence of financial factors on a firm's capital investment decision emerged. In fact, theoretical developments that occurred in the field of information economics, which emphasised the existence of information problems in financial markets, allowed to rationalise a close relationship between financial factors and investment expenses of firms.

This paper aims at contributing to the empirical literature on this subject, presenting the results of an empirical study undertaken for a panel of Portuguese manufacturing firms. The results obtained suggest that the impact of financial factors on investment decisions of firms is greater for those facing higher information problems in financial markets, such as: small, young and low retention firms.

INTRODUCTION

According to the investment models that assume perfect capital markets (e.g. the neoclassical model of Jorgenson, 1963, and the Q-model of Tobin, 1969), the availability of internal funds does not affect investment decisions. Investment outlays in each period are determined in perfectly functioning capital markets. Financial factors are only considered in the cost of capital, which, in turn, is independent of the way in which the firm finances itself. This independence derives from the assumption that capital markets are perfect. Thus, firms can obtain all financing that they need to implement investment projects, providing that the expected marginal return exceeds the cost of capital. In other words, it would not be expected that a company, with a profitable investment opportunity but an investment outlay greater than its available funds, would invest less than a company with the same investment opportunities but with greater cash flow. Any insufficiency will attract finance in capital markets as investors attempt to explore the profit opportunity. This also means that the marginal costs of financing through

debt, external equity capital and internal funds are the same.

In this context, it could be argued that the availability of adequate cash flows is not a restriction on investment and that the financial structure of firms does not affect the cost of capital.

By contrast, the financing constraints model is based, primarily, on the assumption that capital markets are not perfect. In this case, the decision about the sources of finance become extremely important, since the cost of internal funds may diverge significantly from that of external funds. According to Myers (1984), a hierarchy of finance is created, in which the firm starts by using the cheaper funds, i.e. firstly it will use internal funds, secondly debt and, finally, new equity capital.

Therefore, when a company has to decide about its investment expenses, it should consider not only the real aspects of the investment decision (e.g. the output, the relative price of inputs, or technology), but also the financial aspects, namely, the generated cash flows and the level of internal funds, so that the company does not forego valuable investment opportunities.

The designation of this model as the financing onstraints model comes from the basic assumption that, at least, some firms can face financial restrictions. One can say that there are financial restrictions when a company cannot obtain all the amount of finance it needs, irrespective of the opportunity cost of funds. In other words, financial restrictions refer to the situation in which profitable investment projects, that would be undertaken if there were sufficient internal funds in the firm, would be abandoned since the availability of external funds for the company is limited, due to (i) information imperfections in capital markets, and (ii) to the fact that the cost of external funds is greater than that of internal funds (Kim, 1999).

It should be emphasised that the idea of including financial variables in an econometric investment equation is not new. The models that integrated these variables assumed great importance in the 1950's. However, three fundamental reasons justify their abandonment. Firstly, the ad hoc manner in which these variables were included in the econometric investment equations. Secondly, the famous proposition 1 of Modigliani and Miller (1958), which provided the

theoretical foundations required to consider only the real aspects of the investment decision. Thirdly, the empirical results obtained by using these models in comparison with more consistent theoretical ones were poor.

The recent resurgence of investment models that include financial factors is due to two main reasons. The first one is related to the emergence of a new theoretical body that flourished since the 1970's, that emphasises the role played by information problems in financial markets. These are related, on the one hand, to the existence of asymmetric information in financial markets, which leads to adverse selection problems and moral hazard, as the works of Akerlof (1970), Stiglitz and Weiss (1981), Greenwald, Stiglitz and Weiss (1984) and Myers and Majluf (1984) demonstrated, and, on the other hand, to agency problems as stressed by Jensen and Meckling (1976) and Jensen (1986).

The second reason derives from the pioneer empirical study of Fazzari, Hubbard and Petersen (1988). Their empirical research was of great importance for two main reasons. Firstly, these authors emphasise the use of firm-level panel data, which allows obtaining pure microeconomic results, therefore increasing the knowledge on how firms make decisions. Secondly, they abandon the assumption of a representative firm, which was common in the previous studies on the determinants of investment behaviour of firms. A drawback of this procedure is that it does not allow to test whether the sensitivity of investment to cash flows differ according to different types of firms. Consequently, Fazzari, Hubbard and Petersen (1988) argue that when the objective is to test the validity of the financial restrictions model it is necessary to identify, a priori, the type of firms that are included in the sample, i.e. to identify the firms that are more and less subject to information problems in financial markets and, as such, the firms that face a higher differential in the costs of internal and external funds.

In brief, Fazzari, Hubbard and Petersen (1988) proposed a new methodology for evaluating the impact of financial factors on investment decisions of firms. In fact, the basic contribution of the financing constraints model can be stated as follows. Although some kinds of firms can easily obtain external funds to smoothen their investment expenses when internal funds fluctuate, the time and the amount of capital outlays of other firms, with limited or with no access to external funds, will likely be conditioned by fluctuations in internal funds. This fact may give rise to a situation of under investment of firms.

To test this prediction Fazzari, Hubbard and Petersen (1988) proposed a new methodology, which can be described as follows. Firstly, a sample of firms is divided into two sub-samples, according to how much firms are affected by information problems in capital markets, and thus more subject to financial restrictions. Secondly, to verify if there are systematic differences in

the values obtained for the coefficients on financial variables, an econometric investment equation is estimated for each sub-sample, and the results obtained for the coefficients compared.

The predictions of the financing constraints model has been empirically confirmed by several studies for different countries. A significant number of these studies relate to the case of the US economy. Some examples are: Fazzari, Hubbard and Petersen (1988); Whited (1992); Oliner and Rudebusch (1992); Fazzari and Petersen (1993); Vogt (1994); Ramirez (1995); Gilchrist and Himmelberg (1995); Chirinko and Schaller (1995); Calomiris and Hubbard (1995); Hubbard, Kashyap and Whited (1995); Lamont (1997); Stanca and Gallegati (1999); Carpenter and Petersen (2002).

There is, also, wide empirical evidence on the excess sensitivity of investment to cash flows in several European countries, e.g. Bond and Meghir (1994); Fohlin (1998); Deloof (1998); Palenzuela and Iturriaga (1998); Vermeulen (2002); Goergen and Renneboog (2001); Bo, Lensink and Sterken (2003); Bond, Elston, Mairesse and Mulkey (2003); Guariglia (2004); Mizen and Vermeulen (2004).

Finally, more empirical evidence in other countries such as Japan [Hoshi, Kashyap and Scharfstein (1991)]; Canada [Schaller (1993)]; Mexico [Gelos and Werner (2002)]; South Korea [Shin and Park (1999), and Kim (1999)]; and Australia [Mills, Morling and Tease (1995)] can be found.

The aim of this paper is to contribute to the empirical literature on the determinants of capital investment decisions of firms by presenting the results obtained from a sample of Portuguese manufacturing firms.

The remainder of the paper is organised as follows. In Section 2 the hypothesis to be tested are set. Section 3 describes the sample and the variables used. Section 4 identify the criteria used for classifying firms. Section 5 presents the specification adopted for the econometric investment equation. In Section 6 the estimation results are shown. Finally, Section 7 draws the main conclusions, emphasizing the policy implications of the results obtained.

HYPOTHESIS UNDER TEST

To evaluate the impact of cash flows on investment decisions of firms, the methodology proposed initially by Fazzari, Hubbard and Petersen (1988) was adopted.

In this study two key hypothesis are tested. Firstly, the aim is to verify whether investment decisions of firms are affected by cash flows. This fact may derive as a result of a non-perfect substitutability among the different sources of funds that a firm can access, that is, internal funds, debt, and new equity capital. If this is the case, the financial structure of a firm is relevant, which implies that investment and financial decisions are not independent. So, one can conclude that internal funds

are, apart from real variables, an important determinant of business fixed investment.

Secondly, the aim is to test whether the impact of cash flows differs from firm to firm. That is, to determine the extent to which the effect of cash flows on investment decisions of firms is more important for those identified, a priori, as suffering more from information problems in capital markets and, consequently, where the differential between the costs of internal and external funds are higher, thus contributing for the existence of financial restrictions. Hence, the more a firm is exposed to finance constraints the more its investment decisions should be determined by the availability of internal funds.

DATA AND VARIABLES

In the empirical study undertaken, a panel data was used to obtain empirical evidence on whether firms belonging to the Portuguese manufacturing sector face financial restrictions.

The sample used in this study, comprised, initially, about 8090 firms, for a period between 1990 and 2000. This data came from the Central de Balanços do Banco de Portugal.

Since a balanced panel data was used, firms had to respect several criteria to be included in the sample. Firstly, only private firms, belonging to the manufacturing sector, with at least 25 employees, were considered. Secondly, only companies that presented values for all variables and for every year of the period considered were selected. As a result, the final sample comprised a total of 714 firms.

As far as the variables used were concerned, they were computed from the accounting data of the firms selected, and can be described as follows:

- Investment (I): acquisitions of new structures and equipments.
- Stock of capital (K): represented by fixed assets.
- Sales (S): total sales of the firm.
- Cash flow (CF): given by the sum of profits and depreciation.
- Working capital (WC): current assets minus current liabilities.
- Debt (LTD): correspond to the medium- and long-term debt of the firm.

Table 1 shows some descriptive statistics of the firms in the sample. The most relevant features are the following. Firstly, the mean value of the fixed assets held by firms was € 3,311,994. Secondly, the mean value of the investment in fixed assets was € 699,019, whilst the mean value of the investment in working capital was € 131,562. Thirdly, the mean rate of investment in fixed assets was 33%, whilst the mean rate of investment in working capital was 7%. Finally, sales represented, on average, six times the value of fixed assets of the firms considered.

Table 1 – Descriptive statistics for firms of the full sample. Number of observations 7140.

Variables	Full Sample	
	Mean	S. D.
K (€)	3,311,994	6,308,335
I (€)	699,019	1,659,003
ΔWC (€)	131,562	2,748,804
I_t/K_{t-1}	0.331	0.563
$\Delta WC_t/K_{t-1}$	0.068	1.195
S_t/K_{t-1}	6.276	8.187
CF_t/K_{t-1}	0.365	0.623
WC_{t-1}/K_{t-1}	1.143	2.674
$\Delta LTD_{t-1}/K_{t-1}$	0.033	0.516

CRITERIA FOR SPLITTING THE SAMPLE

In this subsection the criteria used to identify firms that face greater financial restrictions, due to information problems in capital markets are described.

Size

The first criterion used to split firms into two groups was the firms' size (a group of large firms and a group of small firms), where size was measured by firms' sales.

According to this criterion, it is assumed that large firms are, a priori, less subject to financial restrictions.

The decision to split the sample according to size can be justified as follows. Firstly, larger companies have an easier access to capital markets, due to the possibility of using the firm's assets as collateral. Secondly, it is likely that transaction and floatation costs for new share or bond issues decrease with dimension. Thirdly, larger companies can use more different sources of funds than small companies, which allow large companies to reduce the risk of financing. Fourthly, larger companies have, in general, to meet more obligations in terms of financial statements produced and information released about their activities and future prospects. Finally, it is likely that small firms suffer more from the idiosyncratic type of risk.

Table 2 shows descriptive statistics for both types of firms, large and small. By comparing the figures for both types of firms, the following conclusions can be drawn. Firstly, the mean values of fixed assets, of investment in fixed assets and of investment in working capital are nine, eight, and eleven times greater for large firms than for small firms, respectively. Clearly, this fact shows how different the firms included in each group are.

Table 2 – Descriptive statistics for firms classified according with size. Number of observations 3570.

Variables	Large Firms		Small Firms	
	Mean	S. D.	Mean	S. D.
K (€)	5,957,508	8,067,413	666,479	718,849
I (€)	1,238,918	2,203,110	159,119	261,752
ΔWC (€)	240,486	3,873,230	22,637	297,184
I_t/K_{t-1}	0.292	0.361	0.370	0.709
$\Delta WC_t/K_{t-1}$	0.042	0.599	0.093	1.580
S_t/K_{t-1}	5.454	5.601	7.098	10.067
CF_t/K_{t-1}	0.338	0.445	0.393	0.760
WC_{t-1}/K_{t-1}	0.851	1.499	1.435	3.448
ΔLTD_t	0.036	0.514	0.030	0.518
$1/K_{t-1}$				

Secondly, the mean rate of investment in fixed assets and the mean rate of investment in working capital are greater for small firms than for large firms (37% vs. 29% e 9% vs. 4%, respectively).

Finally, the proportion of the mean value of sales on the mean value of fixed assets is greater for small firms than for large firms.

Age

The second criterion used to divide firms into two groups was the firms' age (a group of mature firms and a group of young firms).

It is assumed that mature firms are less likely to face information problems in capital markets for: (a) creditors have, in general, more information about mature firms, since they have been visible for a longer period of time, and (b) mature firms can establish continued relationships with creditors and suppliers based on mutual confidence, which helps to overcome information problems.

In Table 3 some descriptive statistics are presented for both types of firms, mature and young.

Table 3 – Descriptive statistics for firms classified according with age. Number of observations 3570.

Variables	Mature Firms		Young Firms	
	Mean	S. D.	Mean	S. D.
K (€)	4,583,178	7,917,781	2,040,809	3,698,288
I (€)	936,291	2,137,560	461,746	907,503
ΔWC (€)	138,967	3,533,964	124,157	1,620,172
I_t/K_{t-1}	0.309	0.579	0.353	0.547
$\Delta WC_t/K_{t-1}$	0.062	1.309	0.073	8.742
S_t/K_{t-1}	5.835	7.337	6.716	8.936
CF_t/K_{t-1}	0.345	0.588	0.386	0.655
WC_{t-1}/K_{t-1}	1.375	3.107	0.911	2.132
ΔLTD_t	0.026	0.621	0.040	0.384
$1/K_{t-1}$				

Table 3 shows that mature firms have mean values for fixed assets and for investment in fixed assets that are twice as great as those of young firms. This is an indication that mature firms tend to be greater than young firms. However, this effect tends to be

counterbalanced, since young firms show a mean rate of investment in fixed assets higher than mature firms (35,3% vs. 30,9%).

It is also important to point out that the mean values for investment in working capital, rate of investment in working capital and the proportion of sales on the stock of fixed assets, are similar in the two groups of firms.

Retention ratio

The last criterion used to classify firms was the profits retention ratio. Hence, there is a group that includes firms with the lowest retention ratio and another composed by firms that have the highest retention ratios. The basic assumption for having used this criterion was that the availability of internal funds can restrict the investment expenses of firms with higher retention ratio. Two reasons justify this rationale, according to Fazzari, Hubbard and Petersen (1988). On one hand, firms may need funds to finance an amount of investment that exceeds their cash flow. So, they opt to retain all internal funds at low cost, which they generated from their normal activity. On the other hand, since dividend payments and investment outlays correspond to alternative uses of funds, companies that face severe restrictions in obtaining finance should choose low dividend payouts.

Table 4 shows descriptive statistics for both types of firms, lower and higher profit retention ratios companies.

Table 4 – Descriptive statistics for firms classified according with retention practices. Number of observations 3570.

Variables	Low Retention Firms		High Retention Firms	
	Mean	S. D.	Mean	S. D.
K (€)	4,046,521	7,194,304	2,577,466	5,173,388
I (€)	794,617	1,840,733	603,421	1,448,714
ΔWC (€)	139,043	3,095,253	124,081	2,352,289
I_t/K_{t-1}	0.304	0.569	0.359	0.557
$\Delta WC_t/K_{t-1}$	0.043	1.297	0.093	1.084
S_t/K_{t-1}	5.526	7.039	7.025	9.132
CF_t/K_{t-1}	0.337	0.643	0.393	0.601
WC_{t-1}/K_{t-1}	1.077	2.503	1.208	2.834
ΔLTD_t	0.029	0.492	0.037	0.540
$1/K_{t-1}$				

The main features are the following. Firstly, companies with a low retention ratio tend to be larger, since they have a mean value for the stock of fixed assets higher than their counterparts (€ 4,046,521 vs. € 2,577,466).

However, the mean values of investment in fixed assets and working capital, although higher for low retention firms, do not differ much in both types of firms. On the other hand, the mean rates of investment in fixed assets and in working capital are higher for high retention firms.

SPECIFICATION OF THE ECONOMETRIC INVESTMENT EQUATION

To test the two hypothesis set forth at the beginning of this section, an econometric investment equation was estimated, based on the specification proposed by Fazzari and Petersen (1993).

The basic idea of this model focuses on the role that working capital may perform in an investment equation, given the possibility that, in some cases, it corresponds to the use of funds and, in other cases, to a source of funds.

The argument, developed by Fazzari and Petersen (1993), is as follows: (a) if firms face restrictions in accessing funds for finance, (b) if fixed investment is relatively irreversible, and (c) if firms want to maintain unchanged their fixed investment, then the two kinds of investment (in fixed and working capital) compete for obtaining finance, due to information problems in capital markets. Hence, it would be expected a negative relationship between fixed investment and working capital investment, since firms use working capital to smooth their fixed investment.

Thus, the specification adopted for the econometric investment equation was the following:

$$I_{it}/K_{it-1} = \alpha_i + \alpha_t + \beta_1(S_{it}/K_{it-1}) + \beta_2(CF_{it}/K_{it-1}) + \beta_3(\Delta WC_{it}/K_{it-1}) + \beta_4(\Delta LTD_{it}/K_{it-1}) + \varepsilon_{it}$$

where I represents firm investment in fixed assets; S corresponds to sales; CF is cash flow; ΔWC represents change in working capital; and ΔLTD is the change in medium- and long-term debt of the firm. All variables are divided by the stock of capital (K) to address the problem of heteroscedasticity. (α_i) corresponds to the firm effect, (α_t) to the year effect and (ε_{it}) is the error term. The subscripts i and t correspond to firm and time, respectively.

The inclusion of the variable sales serves as a way to control investment opportunities faced by firms.

The cash flow variable is a proxy for a firm's internal funds. If these are not important for investment decisions of a firm, the coefficient on the cash flow variable has no statistical significance.

If the estimated coefficient for the variable change in working capital (ΔWC) is negative, this is an indication that firms may face financial restrictions, as suggested by Fazzari and Petersen (1993).

Given that the second main source of funds that a firm can access is debt, the variable change in medium- and long-term debt (ΔLTD) was included to be taken into account the effect that debt might have on investment decisions. The existence of a positive relationship between variation in debt and investment expenses means that firms adjust their financial structure in such a way that allows them to accomplish their investment plans.

ESTIMATION RESULTS

In this subsection we present the estimation results for the specifications of the investment equation adopted and for the various criteria used to split the sample.

All equations were estimated using a fixed effects model, as proposed by Hsiao (2003).

Full sample

Table 5 shows the regression results for the econometric investment equation, considering the full sample. The following conclusions can be drawn from table 5: (a) all explanatory variables are significant at one per cent level, and the estimated coefficients have the sign indicated by theory; (b) there is a positive relationship between investment expenses and cash flow and between the change in the medium- and long-term debt, which suggests the importance of the financial structure of a firm on its investment decisions; and (c) there is a negative relationship between the two types of investment (fixed and working capital), which indicates that firms may face financing restrictions.

Table 5 – Regression results for full sample. Dependent variable, I_t/k_{t-1} . Standard errors are in parenthesis.

Number of observations 7140.	
Independent Variable	Full sample
S_{it}/K_{it-1}	0.026* (0.0013)
CF_{it}/K_{it-1}	0.328* (0.0122)
$\Delta WC_{it}/K_{it-1}$	-0.296* (0.0124)
$\Delta LTD_{it}/K_{it-1}$	0.339* (0.0127)
Adjusted R^2	0.53
DW	1.95

* Significant at 1% level.

Size

Table 6 shows the regression results for the econometric investment equation, when the sample was divided according to firms' size.

Table 6 – Regression results for firms classified according to their size. Dependent variable, I_t/k_{t-1} . Standard errors are in parenthesis. Number of observations 3570.

Independent Variable	Large Firms	Small Firms
S_{it}/K_{it-1}	0.023* (0.0013)	0.026* (0.0019)
CF_{it}/K_{it-1}	0.234* (0.0123)	0.468* (0.0183)
$\Delta WC_{it}/K_{it-1}$	-0.219* (0.0113)	-0.418* (0.0211)
$\Delta LTD_{it}/K_{it-1}$	0.243* (0.0197)	0.495* (0.0183)
Adjusted R ²	0.47	0.59
DW	1.87	2.04

* Significant at 1% level.

The main features of the regression results shown in table 6 are the following. Firstly, although the estimated coefficients of the cash flow variable are statistically significant for both types of firms, the parameter for cash flow for small firms is twice the one for large firms. The results obtained indicate that an increase of one euro on cash flow of small firms leads to an increase of 47 cents on their investment, whilst an identical increase in cash flow of large firms only increases investment on 23 cents.

Secondly, the results shown in table 6 confirm that investments in fixed assets and in working capital compete for the financing available, and that this effect is more important for small firms.

Thirdly, there is a positive relationship between investment and variation in their medium- and long-term debt (ΔLTD). This means that, in order to undertake investment projects, firms adjust their financial structure.

Finally, it is important to point out that although sales were included in the investment equation, cash flow becomes always statistically significant. This fact can be interpreted as an indication that cash flows themselves play a role in explaining investment expenses of firms, and they are not proxying for shifts in investment demand.

Age

Table 7 shows the regression results for the econometric investment equation when the sample was divided by age.

Table 7 – Regression results for firms classified according to their age. Dependent variable, I_t/k_{t-1} . Standard errors are in parenthesis. Number of observations 3570.

Independent Variable	Mature Firms	Young Firms
S_{it}/K_{it-1}	0.028* (0.0012)	0.023* (0.0018)
CF_{it}/K_{it-1}	0.193* (0.0132)	0.485* (0.0177)
$\Delta WC_{it}/K_{it-1}$	-0.165* (0.0118)	-0.456* (0.0181)
$\Delta LTD_{it}/K_{it-1}$	0.200* (0.0129)	0.514* (0.0179)
Adjusted R ²	0.42	0.65
DW	1.89	2.03

* Significant at 1% level.

The following features are noteworthy. Firstly, given that the cash flow coefficient is higher for young firms than for mature firms, it can be argued that young firms tend to suffer more from finance constraints than mature firms.

Secondly, this conclusion is enhanced by the behaviour of the variables investment in working capital (ΔWC) and change in medium- and long-term debt (ΔLTD). On one hand, the fact that both types of investment (in fixed and working capital) compete for the limited availability of funds for investment financing is confirmed and on other hand, there is a positive relationship between investment and change in medium- and long-term debt.

Finally, since sales are statistically significant at one per cent level, this result confirms, on one hand, the importance of the accelerator principle as a determinant for investment expenses of firms and, on the other hand, the need to control the investment opportunities that firms face to evaluate the true impact of financial factors on the investment of companies.

Retention ratio

Table 8 shows the regression results for the econometric investment equation when the sample was divided by profits retention ratio.

Table 8 – Regression results for firms classified according to their retention practices. Dependent variable, I_t/k_{t-1} . Standard errors are in parenthesis.

Number of observations 3570.		
Independent Variable	Low Retention Firms	High Retention Firms
S_{it}/K_{it-1}	0.028* (0.0012)	0.022* (0.0013)
CF_{it}/K_{it-1}	0.180* (0.0113)	0.588* (0.0186)
$\Delta WC_{it}/K_{it-1}$	-0.171* (0.0110)	-0.532* (0.0189)
$\Delta LTD_{it}/K_{it-1}$	0.197* (0.0095)	0.586* (0.0202)
Adjusted R ²	0.42	0.71
DW	1.89	2.07

* Significant at 1% level.

This table shows that although the cash flow variable is statistically significant at a level of one per cent for both types of firms, the estimated coefficient is much higher for firms with high retention ratios (the difference between them reaches 0.408). This result is a clear indication that there are firms that face a finance hierarchy that can be explained by the existence of asymmetric information in financial markets.

From table 8 it is also possible to conclude that: (a) the impact of investment in working capital (ΔWC) and of the change in medium- and long-term debt (ΔLTD) on investment is higher for high retention firms, and (b) sales are an important determinant of fixed capital investment of firms.

Multicriteria

In the previous subsections only one criterion was used each time to classify firms according to the information problems they face in financial markets. The same procedure has been adopted in the majority of the other studies on the investment cash flow relationship. However, as pointed out by Schiantarelli (1996), there is no reason not to use more than one criterion simultaneously to classify firms.

Following this line of reasoning, the three criteria used previously were considered together to obtain empirical evidence about the link between the financial structure of a firm and its investment decisions. As such, the econometric investment equation was regressed for two groups of firms: one with the large, mature and low retention firms, and the other with the small, young and high retention firms.

Table 9 shows the results of the regressions. As it can be seen in the table, the predictions of the financial restrictions model are clearly supported by the results obtained. In fact, the estimated coefficient for the cash flow variable is about ten times greater for small, young

and high retention firms than for large, mature and low retention firms.

Table 9 – Regression results for firms classified according to the three criteria simultaneously. Dependent variable, I_t/k_{t-1} . Standard errors are in parenthesis.

Independent Variable	Large, Mature and Low Retention Firms	Small, Young and High Retention Firms
S_{it}/K_{it-1}	0.024* (0.0016)	0.021* (0.0022)
CF_{it}/K_{it-1}	0.064* (0.0074)	0.652* (0.0318)
$\Delta WC_{it}/K_{it-1}$	-0.064* (0.0055)	-0.589* (0.0292)
$\Delta LTD_{it}/K_{it-1}$	0.103* (0.0098)	0.749* (0.0223)
Adjusted R ²	0.34	0.72
DW	1.77	2.13
Nº Obs.	1240	1160

* Significant at 1% level.

Moreover, the results indicate, also, that the small, young and high retention firms use in greater magnitude the working capital to smooth their fixed investment. This can be interpreted as an indication that these type of firms have more problems in obtaining external funds to finance their investment opportunities.

Finally, small, young and high retention firms tend to adjust in higher magnitude its financial structure to accomplish their investment plans than large, mature and low retention firms.

CONCLUSIONS AND FURTHER RESEARCH

There has been in recent times a growing interest, from empirical researchers, in the study of the determinants of business fixed investment decisions. This interest can be justified by two main reasons. Firstly, investment is a very volatile component of GDP, which means that it can have a great influence over business cycles. Secondly, a new research topic about investment determinants (i.e., the role of financing constraints) was induced by recent developments in information economics.

The aim of this paper was to apply these new theoretical developments to the case of the Portuguese manufacturing industry. In fact, two key hypotheses were tested. On one hand, financial factors are, apart from the real variables, important determinants of business fixed investment. On the other hand, the effect of financial factors is more important for firms that are, a priori, more exposed to information problems and, hence, where the severity of financial constraints is more acute.

The findings of the empirical study confirm both hypotheses set in this study. In fact, the results obtained

showed that financial factors have an impact on investment decisions of all firms, and that this influence is greater for those facing higher information problems in financial markets, such as: small, young and low retention firms.

In terms of policy implications, the strong connection between firms' financial status and investment, suggests that in the case, for example, of a restrictive monetary policy the real economy will be affected not only through the traditional channel of the cost of capital, but also through the availability of funds channel, which means that an increase in interest expenses of firms will reduce the availability of relatively cheap internal funds and increase the cost of external funds.

Another important policy implication resulting from this study is the impact of tax policy changes. The main argument is that, when firms face limitations in obtaining finance due to imperfections in the financial markets, any increase in the tax revenue coming from tax charged to firms has a negative impact on investment, since it limits the availability of funds to which the company can access to achieve its investment plans. Therefore, it could be argued that tax policy measures such as the reduction in corporate tax rate, measures that disincentive high dividend payouts, accelerated depreciation allowances, and the introduction of an investment tax credit, could induce more investment in fixed capital by firms.

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WHICH PROJECT CHARACTERISTICS ARE IMPORTANT? WHAT ARE THE PROJECT SUCCESS FACTORS?

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Non-Financial issue; Project Success; Capital budgeting

ABSTRACT

The evaluation process of real investment projects must consider not only the traditional financial approach, but also non-financial aspects that can provide additional relevant information about projects. We investigate financial and non-financial areas most relevant in project appraisal, main critical success factors and areas of analysis that lead to the perception of project success, through nine hypotheses that are empirically tested. Companies are also segmented to verify their financial and non-financial practices, considering industries, type of project, size and duration of the project. The results show that non-financial factors affect the investment decision with larger importance than financial ones, specifically the strategic, technical and commercial areas. Perceived success of a project is related to the consideration of strategic, political and human resources aspects in its evaluation. There is a greater perception of success when companies attribute greater importance to financial and commercial aspects in project appraisal. The existence of many financial and strategic factors is associated with a greater perceived success of the project. We found that there is a greater perception of success in companies with larger projects, when the chairman of the board has higher tenure and when the project manager has a higher education degree and has variable reward.

1. INTRODUCTION

Investment decision making is relatively simple when only financial criteria are taken into account (Lopes and Flavell (1998)). However, if we use non-financial criteria to improve our evaluation it is important to understand that there are a lot of aspects which we have to take into account, and most of them are not easily measured. Non-financial analyses can provide additional relevant information to the decision making.

The non-financial aspects that we have to consider in project appraisal, in addition to the financial aspects, are strategic, technical, commercial, political, social,

environmental, organizational, human resources and management (Skitmore, et. al., 1989; Adler, 2000; Chen, 1995; Meredith and Mantel, 2000; Love et. al., 2002; Kendra and Taplin, 2004; Moutinho and Lopes, 2010). The best way to analyse an investment project is to take into account all financial and non-financial areas.

Several authors refer to different variables as being able to explain the practice of companies. Pike (1983) states that investment procedures depend on the "nature of the company (size, capital intensity, and organizational structure), the characteristics of the external environment, and the complexity of the projects reviewed". According to Chen (1995) "deciding which features to investigate is not a trivial task, due to our limited knowledge of the relationships between the characteristics of business and technical analysis of projects". Given the relevance non-financial aspects can take in evaluating an investment project, it is very important to know how the characteristics of the company, the project, the administration and the project manager can affect the analysis.

As in Graham and Harvey (2001), the most interesting results come from the study of responses conditioned by the characteristics of the company and company management, such as size (Drury and Tayles, 1996 and 1997; Schall et. al., 1978; Kim, 1982), debt and payment of dividends, debt rating, and industry (Belassi and Tukel, 1996; Belout and Gauvreau, 2004), management ownership, age, tenure and CEO qualifications. Rodrigues (1999) adds that the academic qualifications and the manager's compensation scheme should also be considered. In this sense, Block (2005) concludes that the characteristics of firms affect investment decisions.

Moreover, Dvir et. al. (1998) suggest that "the success factors of a project are not universal for all projects. Different projects exhibit different success factors". As the most relevant features, we find, in the existing literature, the type of project (Chen, 1995; Dvir et. al., 1998; Petty et. al., 1975; Klammer, et. al., 1991), size (Chen, 1995; Schall et. al., 1978; Belassi and Tukel, 1996; Dvir et. al., 1998), duration (Mohamed and McCowan, 2001), and risk (Ho and Pike, 1991; Petry and Sprow, 1993).

This paper is organized as follows: In next section, we present our hypothesis. In section three we present the research methodology used. Then we present and discuss the results. Finally, we give our conclusions.

2. Research Hypothesis

The evaluation of non-financial aspects tends to influence investment decisions through the cash flows and/or the discount rate of the project. However, we may not see any impact of non-financial aspects in the investment decision if they are not relevant to the project. Thus, we seek to study the importance of financial aspects, as well as the strategic, technical, commercial, political, social, environmental, organizational, human resources and project manager's dimensions. Thus, we will analyze the following hypotheses:

Hypothesis 1: *The financial and non-financial project evaluation areas are relevant to the investment decision.*

Non-financial areas may take relevance in project appraisal. So, it is important to know how the characteristics of the company, project, management and project manager can affect the analysis of each area. It is therefore important to know which factors may influence the analysis of each area:

Hypothesis 2: *The analysis of each dimension in project evaluation is associated with:*

H2a: *company characteristics*

H2b: *project characteristics*

H2c: *management characteristics*

H2d: *project manager characteristics*

The success of the project, whose definition remains ambiguous because it can have different meanings to different people due to various perceptions that exist anywhere (Liu and Walker, 1998), is the result of the previous analysis of financial and non-financial factors, which may lead companies to a certain investment decision.

Many authors show a number of factors that lead to the viability and success of a project (Lopes and Flavell, 1998; Belassi and Tukul, 1996, among others). These factors are basically aspects of strategic, technical, commercial, political, environmental, organizational, social, human resources and project manager areas.

Before analyzing individual factors, we must first be able to identify what critical dimensions they belong to a better evaluation of the project. One of the advantages of grouping the factors in various homogeneous dimensions is that even though identifying specific success factors is difficult, identifying if the success or failure is related to each dimension of analysis is much easier. Based on the idea that each dimension of analysis can contribute to project success we test the following hypothesis:

Hypothesis 3: *The success of the project is associated with the analysis of each dimension of evaluation.*

After the identification of critical areas for the project success, we would like to clarify which factors are critical to the success of the project. Pinto and Slevin (1988, 1989), Pinto and Prescott (1988), Belassi and Tukul (1996), Shenhar et al (2002), Belout and Gauvreau (2004), Dvir et. al. (1998), Skitmore et al (1989), Ashley et al (1997), White and Fortune (2002) and Cooke-Davies (2002) suggest a variety of critical success factors for a number of different dimensions of analysis. Based on this evidence, we analyse, within each dimension of analysis:

Hypothesis 4: *Which factors are associated with the success of the project.*

Dvir et. al. (1998) suggest that "the success factors of a project are not universal for all projects. Different projects exhibit different success factors". The importance of the factors conditioning the project is supported by extensive literature (eg: Chen, 1995; Graham and Harvey, 2001; Shenhar et. al., 2002). These suggest that the practices of companies may be constrained by the characteristics of the company, project, management and project manager. Belassi and Tukul (2004) suggest that critical factors are different across industries and project sizes. Shenhar et. al.(2002) show the project type as a conditioning feature. Thus, we will study the following assumptions:

Hypothesis 5: *The success of the project is associated with:*

H5a: *company characteristics*

H5b: *project characteristics*

H5c: *management characteristics*

H5d: *project manager characteristics*

This study also takes into account the impact of industry in the project analysis and success. Belassi and Tukul (1996) suggest that the study of various non-financial aspects and the success/failure factors may prove critical to the project and tend to vary in importance depending on the sector. Pinto and Covin (1989) refer that the industry (of the project) influences the importance of different success factors. Also Belout and Gauvreau (2004) refer that the relationship between several aspects to the success of a project depends on the sector. Moreover, Graham and Harvey (2001) show differences in attitudes of the companies, in the financial area. So we test the following hypothesis:

Hypothesis 6: *The critical areas in project success and the analysis of each area of project evaluation depend on the industry.*

The success factors are not universal, as they may diverge with different features of the project. For Dvir et. al. (1998) and Shenhar et. al. (2002) the success and the importance of various aspects may differ depending on the type of project. We seek to confirm this idea:

Hypothesis 7: *The critical areas in project success and the analysis of each area of project evaluation depend on the type of project.*

Another factor that could influence the success and evaluation of various areas is the size of projects. Graham and Harvey (2001), Belout and Gauvreau (2004) and Dvir et. al. (1998) show size as one of the factors that can affect projects, so we study the following hypothesis:

Hypothesis 8: *The critical areas in project success and the analysis of each area of project evaluation depend on the size of the project.*

Finally, the projects are analyzed for their period duration. For Mohamed and McCowan (2001) the period duration is a relevant factor to consider for the success of the project.

Hypothesis 9: *The critical areas in project success and the analysis of each area of project evaluation depend on the period duration of the project.*

3. Methodology

After developing a preliminary version of the questionnaire, we have made two personal interviews with financial directors of companies in the sample, in order to validate the points covered. This test allows the clarification of the importance of the study. The data for this study were obtained from a questionnaire sent to the biggest Portuguese companies in 2005 and we have obtained a response rate of 9,6%. This questionnaire is the same as in Moutinho and Lopes (2010).

Concerning the characteristics of the firms surveyed, we distinguish among the sectors where they operate, the type of project implemented, the size and duration of the project. Of the respondents to the questionnaire 37 (39.8%) are in the manufacturing industry, 24 (25.5%) are in the commerce industry, 16 (%) are in the transportation/energy industry and the remainder are from other sectors. Companies execute a variety of types of projects, with 47 (49%) companies having implemented expansion projects, 38 (39.6%) projects to modernize and 16 (16.7%) replacement projects. We analyze 29 (34.5%) large projects and 36 (42.9%) small projects, while 35 (39.8%) projects are implemented in the long term (more than 24 months) and 53 (60,2%) projects are implemented in the short term (implemented in less than 24 months).

4. Research Results

Hypothesis 1: *The financial and non-financial project evaluation areas are relevant to the investment decision.*

In order to know the area of analysis considered in projects we analyze which percentage of those surveyed have done each type of analysis. Panel A of Table 1 reveals that strategic analysis (95.8%) is the most used

project evaluation area, followed by financial, technical and commercial evaluation, which were analyzed by 85.4 %, 83.3% and 78.1% of the companies, respectively. On the other hand, only 40.6% of the companies took into account social aspects and 43.8% consider the political aspects in project evaluation.

[Insert Table 1]

From panel B we find that the most important areas in the project evaluation are strategic analysis and technical analysis. The financial analysis only comes in third place, together with the commercial analysis. The sample also shows that 69.8% of companies consider project manager aspects important or very important. Political analysis and social analysis are the least relevant in this context.

In the factors that influence the economic value of the project (Panel C) we highlight the importance given to strategic analysis (94.8%), followed by technical analysis (78.1%). Financial analysis (74%) only comes in third place. Again, political analysis (19.8%) and social analysis (21.9%) have very little influence in the economic value of the project.

For the importance of each of these aspects (financial or non-financial) in decision-making (Panel D), we show a high relevance of strategic analysis (97.8%). However, other areas are also relevant, such as technical analysis (79.6%), financial analysis (76.3%) and commercial analysis (72%). Social analysis (15.1%) and political analysis (16.1%) are the least relevant for decision making. Once again the importance attached to each analysis is similar to that in previous analyses.

The data presented reveals the possible areas of evaluation more relevant to investment decision. The companies consider the strategic analysis as the most relevant for the project appraisal, followed by the study of technical, financial and commercial aspects. In contrast, political and social analyses are pointed out as having the least relevance to investment projects. These results confirm the importance of studying the factors that influence the project evaluation. We show that there are other factors, in addition to financial, that affect the investment decision with great prevalence.

Hypothesis 2: *The analysis of each dimension in project evaluation is associated with:*

H2a: *company characteristics*

H2b: *project characteristics*

H2c: *management characteristics*

H2d: *project manager characteristics*

To analyze this point we have to do different analysis for each type of features. First, we want to identify the company's characteristics that can influence the likelihood of considering each area in project appraisal. Table 2 reveals that commerce industry is less likely to perform financial, technical analysis and policy analyses. The manufacturing companies are less likely to

make commercial analysis. The probability that companies carry out social analysis is greater in large companies. In the transportation/energy industry the companies are more likely to perform social analysis. Project manager analysis is more likely to occur in large companies and companies with low debt.

[Insert Table 2]

Then, we seek to understand which project's characteristics might influence the study of numerous project evaluation aspects, as shown in table 3. The data show that companies that implement modernization projects are less likely to consider financial and social analyses. The results show a higher probability of making technical analysis on projects of longer duration, political and environmental analyses in large scale projects, organizational analysis in small scale projects, and project manager analysis in large projects. In expansion projects there is a greater probability of performing the commercial analysis.

[Insert Table 3]

Then, we identify the company's management characteristics that influence each dimensions of analysis. Table 4 shows that the younger the chairman of the board, the more likely it is that the company performs strategic analysis. Technical analysis is less likely to occur when the company's manager is also a shareholder. While environmental analysis have a propensity to be done by companies in which the chairman of the board is at least graduated, organizational analysis tends to be carried out when management is also owner of capital. If the chairman of the board has low tenure there is a great probability of doing the political analysis in project evaluation.

[Insert Table 4]

Next, we analyze how project manager aspects can affect the probability of doing each analysis. Table 5 shows a greater likelihood to perform financial analysis when the project manager has a position in the company's management and when his reward is fixed, political analysis when the project manager is older, and environmental analysis if the manager has higher education level, and project manager analysis when he is older. On the other hand, it is less likely that companies perform technical analysis when the project manager is in the company management and has extensive experience in project management, organizational analysis in the presence of an older manager, human resources analysis when the manager has a lot of experience in project management, and project manager analysis in the case of belonging to the company's management.

[Insert Table 5]

Finally, we also examine whether investment decision by different stakeholders in the company can influence the likelihood of performing each of the different analysis. In conclusion, through regressions not reported, the investment fact that the decision is made by management or by another member of the company outside management does not interfere in the practices of companies running various analyses and does not influence the perception of project success.

Hypothesis 3: *The success of the project is associated with the analysis of each dimension of evaluation.*

Although there are many factors under the control of managers, there are many others beyond managers' control that determine the success or failure of the project (Belassi and Tukel, 1996). Due to the unique nature of each project, many of the success factors are not applied to another project and the success is typically a combination of many factors.

Apparently, there may be ambiguity in determining the success or failure, because different parties involved in a project perceive the success or failure differently (Pinto and Slevin, 1989). A project that is perceived as successful by some may be perceived as a failure by others.

Although Baccarini (1999) lists the main features of the criteria for project success and Dvir et. al. (1998), Freeman and Beale (1992), Lipovetsky et. al. (1997) and Collins and Baccarini (2004) point out various criteria and measures of success, de Wit (1988) concludes that "to think you can objectively measure the success of a project is an illusion". Thus, Baker et. al. (1988) suggest the use of the term perceived success of a project, a suggestion that was adopted.

Panel A of Table 6 highlights that the perception of success of a project is related to the consideration of strategic, political and human resources analyses in project appraisal. In this analysis we also find that social and organizational analyses tend not to contribute very much to the perceived success of projects in the sample companies. Based on Panel B we verify a greater perception of success when companies attach greater importance to financial and commercial aspects. Panel C shows a positive relation between financial and strategic factors and the perceived success of the project. Companies that take into account a large number of organizational factors tend to have a low perception of success.

[Insert Table 6]

Hypothesis 4: *Which factors are associated with the success of the project.*

Moutinho and Lopes (2010) found that the critical success factors are dispersed in various areas of analysis. They found "a wide array of non financial

aspects was considered critical in the project evaluation". They also mention other factors as main critical success factors: deadline, quality, costumer's satisfaction, speed of implementation and partnership with clients. In this study, in order to identify the critical success factors, we have done regressions, not reported, between the perceived success of the project and each one of the factors considered in each area of analysis. Table 7 presents, summarizing, all variables to which the perception of success is significantly associated.

[Insert Table 7]

Hypothesis 5: *The success of the project is associated with:*

H5a: *company characteristics*

H5b: *project characteristics*

H5c: *management characteristics*

H5d: *Project manager characteristics*

Table 8 shows that there are several characteristics associated with the success of a project. The results show a perception of success in companies with larger projects, when the chairman of the board is already in that job for a long time and when the project manager has a higher degree and his compensation is variable.

[Insert Table 8]

Hypothesis 6: *The critical areas in project success and the analysis of each area of project evaluation depend on the sector.*

Because of sample size, we only study the most important areas in manufacturing, in commerce and in transport/energy industry. In addition to studying the relevance of each analysis, we try to also analyse the influence of each in the success of the project.

[Insert Table 9]

In manufacturing industry, panel A of Table 9 shows a greater importance of strategic and technical analysis, with the financial analysis appearing as the third most important. Although commercial analysis can be considered the fourth most important, environmental and human resources analyses are further analyzed by companies in this sector. Social and political analyses are the less relevant. In the success of the project, the analysis of social undertakings in manufacturing companies tends not to be perceived as contributing to the success of the project. While the allocation of great importance to financial aspects in project evaluation is associated with a high perception of success in these projects, the importance attributed to political analysis has not the same effect. Furthermore, although the consideration of many of strategic factors (measured by the construction of the index, in panel A.5) is associated with the perceived success of the project, the same is not the case with organizational factors.

Also in commerce industry (see panel B of Table 9) strategic analysis is the most important, followed by commercial and financial analysis. Although nearly 70% of companies consider aspects of human resources, they consider that this area contributes relatively little to the economic value and for investment decision making. There is a low relevance of technical aspects in this sector. Panel B.3 shows that environment and human resources analyses contribute positively to the perceived success of the project. The assignment of high importance to financial analysis in project evaluation is associated with perception of project success in these companies.

In transportation/energy industry, the strategic, technical and commercial analyses are the most relevant, followed by financial and political analysis (see panel C). All companies examined strategic and technical areas. Despite the lack of importance attributed to political and social aspects, over 80% of the sample companies take these into account in project evaluation. From the remaining analysis, the companies also highlight the environmental analysis. While assigning importance to financial and human resources analysis in the assessment is associated with perception of success of these projects, organizational aspects has not the same effect. Although the considerations of many financial and technical factors (measured by the index) are associated with perception of project success, is not the case with the factors of human resources.

In conclusion, the results seem to confirm the differences in the success of a project and the areas evaluated in the project depending on the sector.

Hypothesis 7: *The critical areas in project success and the analysis of each area of project evaluation depend on the type of project.*

Due to the characteristics of the sample, we analyze projects of expansion, modernization and replacement. In expansion projects (see panel A of Table 10) all companies consider strategic issues in assessment. In addition, commercial, financial and technical aspects are also very relevant. Although the study of environmental, human resources and project manager analyses is relevant to project evaluation, these are not important to the economic value of the project or to the investment decision making. Although the importance of financial evaluation and the consideration of financial and human resource factors are associated with perception of project success, the same is not true with commercial and organizational factors.

Technical analysis is more relevant in evaluation of modernization projects, as shown in panel B. Strategic, financial and commercial analyzes are of great importance in the evaluation of investments. The social and organizational aspects are the least relevant. From the other analyzes we highlight the project manager aspects. Perceived success of a project is positively

related, with higher importance on financial aspects during the evaluation of the project.

Technical analysis is the most relevant, followed by strategic and financial analyses in replacement projects. The data allow us to observe that 62.5% of companies look at environmental aspects and 75% of companies look at human resources analysis. When compared with other types of projects, there is a small importance attributed to commercial analysis and we observe consideration of the political aspects in half of the projects. The regressions presented allow us to verify the absence of analyses that significantly influence the perception of project success by the company.

These findings support the conclusion of hypothesis 9 for the reason that the type of project can determine the success factors and the importance given to the areas of assessment.

[Insert Table 10]

Hypothesis 8: *The critical areas in project success and the analysis of each area of project evaluation depend on the size of the project.*

Here we study the factors most relevant to small and large projects. Panel A of Table 11 shows the importance attributed to several areas of analysis in large scale projects. The strategic, technical and financial analyses are the most relevant to the project appraisal. Even though commercial aspects are also important, they appear less relevant to the economic value and decision making. Furthermore, environmental issues are analyzed in 86% of companies and prove to be of great importance in this context. Although not relevant, political and social aspects are taken into account in the analysis of large projects by 68.97% and 55.17% of companies, respectively. The regressions suggest that the importance attributed to financial aspects in project evaluation and the consideration of a large number of technical, human resources and project manager factors are associated with perception of project success, while the use of technical and organizational factors do not have the same effect.

In small projects strategic analysis is the most relevant, followed by commercial, technical and financial analyses (see table 11 below). Note that the financial analysis, which is performed by almost 82% of companies, has a relatively small importance when compared to other analyses. Social, political and environmental analyzes are the least relevant. Panel B.3, B.4 and B.5 emphasize that social and organizational aspects are not related to higher perceptions of project success by companies. Moreover, the attribution of importance to technical and political aspects in evaluation is associated with higher perceptions of project success. Again we note that another constraint factor, project size, tends to affect the type of analysis to be performed and success factors.

[Insert Table 11]

Hypothesis 9: *The critical areas in project success and the analysis of each area of project evaluation depend on the period duration of the project.*

Panel A of Table 12 shows that, in short-term projects, a larger relevance is attributed to strategic issues, followed by financial, commercial, and technical aspects. The fifth aspect further analyzed in evaluation of short-term projects is human resources, with little importance. Social and political analyses are even less relevant. The regressions show a perception of project success when political and environmental aspects are taken into account, when high importance is assigned to financial and environmental aspects and when a large number of environmental factors is considered in project evaluation. When social and organizational analyses are performed, when importance is attributed to social aspects in the assessment and when many commercial and organizational factors are considered, the perceived success of a project tends to be lower.

Panel B presents strategic and technical analyses as the most relevant in assessing long-term projects, followed by financial analysis. Even though the political dimension is analyzed by 65.71% of companies, it is not given great importance, as happens with the social analysis. There is a relative importance of organizational analysis in the context of long-term projects. It is also obvious that the attribution of importance to financial aspects and the consideration of many strategic factors in project evaluation are related to the perception of project success, which does not occur with organizational factors.

It is concluded that period duration of a project can also lead to identification of different success factors and relevance of different analysis.

[Insert Table 12]

5. Conclusion

We have verified the importance of financial and non-financial aspects during the evaluation process and in investment decision making. We show companies' characteristics (like industry, project, management and project manager) are associated with the use of each type of analysis. In this sense, we find which methods and structure are used by companies when they have to analyze each area of the analysis. Another relevant issue is not only the dimensions of analysis relevant to the perceived success of projects, but also the critical success factors for projects, including the critical success factors by area of analysis. Finally, we have done similar tests separating the companies by industries, project types, duration and size of projects.

The results of our analysis allow us to draw some conclusions. It is evident that there are other important factors in addition to financial that affect the investment

decision. Companies consider the strategic analysis the most relevant for the project appraisal, followed by the study of technical, financial and commercial areas.

In the commerce industry there is a lower possibility of performing the financial, technical and political analysis. The manufacturing firms are less likely to make the commercial analysis. The probability of companies to do social analysis is greater when the company is large. The transportation/energy industry is more likely to perform social analysis. The analysis of project manager aspects is more likely to occur in large companies and in low debt companies.

Companies that put into practice modernization projects are less likely to perform the financial and the social analysis. There is a higher probability of making technical analysis on projects of longer duration, political and environmental analyses in large scale projects, and organizational analysis in small-scale projects. The expansion projects are more likely to include commercial analysis.

Furthermore, in company's management characteristics, the younger the chairman of the board, the more likely it is that the company performs strategic analysis. Technical analysis is less likely to occur in cases where the company's manager is a shareholder. Environmental analysis tends to be performed by companies in which the chairman of the board has a degree, and organizational analysis tends to be carried out when the management is also owner of capital. If the chairman of the board is not long in that position, political analysis is more likely to be carried out in project evaluation.

With regard to the characteristics of the project manager, it is more likely to find financial analysis is performed when the project manager occupies a position of management in the company and when his reward is fixed, political analysis when the project manager is older, environmental analysis if the manager has higher education, and project manager analysis when he has an advanced age. On the other hand, there it is less likely to find: technical analysis when the project manager is in the company's management and when he has extensive experience in project management; organizational analysis in the presence of an older manager; human resources analysis when the manager has experience in project management; project manager analysis in the case of belonging to the company management.

The perceived success of a project is related to the consideration of strategic, political and human resources analysis in their evaluation. There is a greater perception of success when companies attribute greater importance to financial and commercial aspects in evaluation of projects.

In our analysis we show the critical success factors for each area of analysis and the characteristics of the company, project, management and project manager associated with the perceived success of the project. We found that there is a greater perception of success in companies with larger projects, when the chairman of

the board is already in that job for a long time and when the project manager has academic training and variable reward. When we split the sample by segments, it seems to confirm the differences in the success of the project and the areas evaluated in the project according to the industry, the type of project, size and duration of the project.

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Table 1: Analyzing Financial and Non Financial Area

This table presents four tests. Panel A indicates the dimensions of analysis used in evaluating projects. Panel B shows the importance attributed to each of the areas in the project evaluation. Panel C shows the influence of each area of analysis on the economic value of the project. Panel D indicates the importance of each area of analysis for making investment decision. Source: Moutinho and Lopes (2010). (N = 96)

Analysis	Panel A		Panel B		Panel C		Panel D	
	Freq.	%	Average	% Important and very Important	Average	% Important and very Important	Average	% Important and very Important
Strategic	92	95,8	3,45	91,7	3,44	94,8	3,67	97,8
Technical	80	83,3	3,28	86,5	3,06	78,1	3,02	79,6
Commercial	75	78,1	2,9	75	2,68	67,7	2,76	72
Political	42	43,8	1,47	20,8	1,28	19,8	1,11	16,1
Finance	82	85,4	2,97	75	2,91	74	3	76,3
Social	39	40,6	1,8	33,3	1,31	21,9	1,22	15,1
Environmental	60	62,5	2,3	55,2	1,99	44,8	1,96	44,1
Organizational	59	61,5	2,43	57,3	1,98	45,8	1,97	46,2
Human Resources	67	69,8	2,3	53,1	1,85	36,5	1,78	32,3
Project Management	53	55,2	2,71	69,8	1,96	44,8	2	41,9

Table 2: Financial and Non-Financial Analysis by Company Characteristics

This table shows the results of multivariate analysis, by logit model, between the likelihood of analyzing each of the dimensions of the project evaluation and the characteristics of the company. In addition to the coefficient of the variable is presented in brackets, the standard deviation associated to it. ***, ** And * show the existence of statistical significance at 1%, 5% and 10% respectively. (N = 86)

	Finance	Strategic	Technical	Commercial	Political	Social	Environmental	Organizational	Human Resource	Project Management
Constant	-2.458 (-0.398)	-0.898 (-0.077)	0.482 (0.073)	-0.266 (-0.053)	0.324 (0.071)	-7.292 (-1.506)	-10.601 ** (-2.286)	-0.625 (-0.158)	-4.618 (-0.971)	-1.529 (-0.362)
Ln(sales)	0.653 (1.565)	-0.062 (-0.107)	0.338 (0.756)	0.341 (1.067)	-0.108 (-0.397)	0.580 ** (2.190)	0.340 (1.416)	-0.164 (-0.731)	0.319 (1.149)	0.699 ** (2.337)
Ln(debt)	-0.333 (-1.213)	0.289 (0.494)	0.073 (0.161)	-0.183 (-0.814)	0.151 (0.723)	-0.161 (-0.765)	0.287 (1.346)	0.220 (1.126)	0.027 (0.128)	-0.577 ** (-2.369)
Public	-1.071 (-0.768)	39.761 (0.000)	-1.140 (-0.582)	-1.277 (-1.119)	0.226 (0.228)	-3.041 ** (-2.004)	-0.309 (-0.315)	0.211 (0.222)	0.750 (0.633)	0.118 (0.126)
Dividends	0.231 (0.282)	0.849 (0.601)	-2.352 ** (-2.128)	0.253 (0.393)	-0.596 (-1.105)	-1.321 ** (-2.329)	-0.221 (-0.434)	0.027 (0.055)	-0.915 * (-1.689)	-0.676 (-1.346)
Private Firm	0.124 (0.156)	1.277 (0.905)	-2.049 * (-1.755)	0.494 (0.803)	-0.714 (-1.317)	-0.347 (-0.629)	-0.008 (-0.014)	0.095 (0.189)	-0.434 (-0.761)	0.399 (0.761)
Commerce industry	-2.559 * (-1.914)	-0.744 (-0.418)	-5.123 *** (-2.726)	-1.908 (-1.636)	-1.888 ** (-2.304)	-0.560 (-0.712)	-0.456 (-0.628)	0.201 (0.293)	0.330 (0.406)	-1.074 (-1.478)
Manufacturing industry	-0.642 (-0.467)	-0.939 (-0.532)	-1.417 (-0.816)	-2.109 * (-1.864)	-0.545 (-0.822)	0.158 (0.223)	0.912 (1.295)	0.228 (0.356)	0.197 (0.268)	-0.972 (-1.428)
Transport/Energy industry	-0.995 (-0.613)	40.191 (0.000)	38.074 (0.000)	0.168 (0.106)	1.131 (1.169)	2.547 ** (2.387)	-0.330 (-0.395)	0.286 (0.345)	-0.201 (-0.218)	0.364 (0.395)
McFadden R-squared	0.148	0.141	0.542	0.138	0.201	0.209	0.119	0.019	0.071	0.115
LR statistic	9.142	3.665	41.422	12.169	23.799	24.324	13.667	2.139	7.184	13.672
Probability(LR stat)	0.330	0.886	0.000	0.144	0.002	0.002	0.091	0.976	0.517	0.091

Table 3: Financial and non financial analysis by project characteristics

This table shows the results of multivariate analysis, by logit model, between the likelihood of analyzing each of the dimensions of the project evaluation and project characteristics. In addition to the coefficient of the variable is presented in brackets, the standard deviation associated to it. ***, ** And * show the existence of statistical significance at 1%, 5% and 10% respectively. (N = 79)

	Finance	Strategic	Technical	Commercial	Political	Social	Environmental	Organizational	Human Resources	Project Manager
C	0.981 (0.292)	-49.109 (-1.173)	-1.328 (-0.336)	-1.242 (-0.366)	-14.291 *** (-3.577)	-3.198 (-1.163)	-10.141 *** (-3.231)	4.967 * (1.809)	-0.363 (-0.137)	2.999 (1.083)
Replacement	0.449 (0.497)	-4.299 (-1.343)	-0.165 (-0.155)	0.543 (0.644)	0.942 (1.029)	-1.252 (-1.287)	0.048 (0.065)	-0.114 (-0.166)	0.492 (0.632)	-0.705 (-1.026)
Modernization	-2.006 *** (-2.653)	6.868 (1.012)	-0.632 (-0.603)	0.594 (0.737)	-0.401 (-0.463)	-1.959 ** (-2.154)	0.049 (0.067)	-0.562 (-0.854)	-0.543 (-0.754)	0.255 (0.397)
Expansion		47.579 (0.000)	-1.212 (-1.132)	1.701 * (1.837)	-0.666 (-0.699)	-1.221 (-1.326)	0.251 (0.322)	-0.307 (-0.431)	-0.406 (-0.535)	-0.278 (-0.394)
Duration	0.023 (0.783)	0.000 (1.539)	0.117 ** (2.057)	-0.014 (-0.668)	0.040 (1.616)	0.018 (1.003)	0.001 (0.061)	0.027 (1.488)	-0.007 (-0.419)	-0.017 (-0.976)
Size	0.086 (0.352)	3.028 (1.169)	0.150 (0.526)	0.081 (0.334)	0.897 *** (3.409)	0.250 (1.322)	0.729 *** (3.308)	-0.328 * (-1.715)	0.113 (0.609)	-0.187 (-0.965)
Relative size	0.172 (0.223)	60.102 (0.955)	2.422 (0.688)	8.371 (1.587)	-0.663 (-0.961)	-0.185 (-0.282)	-1.197 (-1.613)	1.144 (1.401)	0.222 (0.293)	1.921 * (1.667)
McFadden R-squared	0.151	0.682	0.263	0.160	0.365	0.141	0.192	0.044	0.029	0.073
LR statistic (6 df)	10.134	17.395	17.674	13.193	39.219	14.683	20.136	4.6002	2.792	7.962
Probability(LR stat)	0.072	0.0079	0.007	0.040	0.000	0.023	0.003	0.596	0.834	0.241

Table 4: Financial and non financial analysis by management characteristics

This table shows the results of multivariate analysis, by logit model, between the likelihood of analyzing each of the dimensions of the project evaluation and the characteristics of company management. In addition to the coefficient of the variable is presented in brackets, the standard deviation associated to it. ***, ** And * show the existence of statistical significance at 1%, 5% and 10% respectively. (N = 87)

	Finance	Strategic	Technical	Commercial	Political	Social	Environmental	Organizational	Human Resources	Project Manager
C	3.880 ** (2.085)	7.359 ** (2.180)	2.485 (1.204)	1.552 (0.888)	-1.441 (-0.968)	-1.326 (-0.967)	-0.131 (-0.093)	2.659 * (1.758)	2.942 * (1.884)	0.907 (0.667)
Degree	0.185 (0.249)	0.921 (0.661)	0.744 (1.012)	-0.278 (-0.369)	0.608 (1.066)	-0.333 (-0.610)	1.119 ** (2.007)	0.171 (0.288)	-0.575 (-0.909)	-0.802 (-1.426)
Age	-0.043 (-1.320)	-0.114 * (-1.954)	0.027 (0.732)	-0.009 (-0.314)	0.031 (1.130)	0.029 (1.175)	-0.003 (-0.126)	-0.044 (-1.594)	-0.024 (-0.89)	0.006 (0.231)
Tenure	0.007 (0.175)	0.144 (1.301)	-0.065 (-1.481)	0.071 (1.394)	-0.064 * (-1.767)	-0.011 (-0.332)	-0.008 (-0.252)	-0.048 (-1.389)	-0.042 (-1.223)	-0.014 (-0.438)
Capital	-0.076 (-0.118)	0.259 (0.211)	-2.186 ** (-1.996)	-0.144 (-0.248)	-0.152 (-0.320)	-0.364 (-0.787)	0.406 (0.825)	1.232 ** (2.367)	0.298 (0.586)	-0.419 (-0.905)
McFadden R-square	0.025	0.199	0.212	0.039	0.075	0.019	0.049	0.095	0.032	0.023
LR statistic (4 df)	1.884	6.476	13.989	3.418	9.030	2.265	5.564	10.830	3.386	2.755
Probability(LR stat)	0.757	0.166	0.007	0.490	0.060	0.687	0.234	0.028	0.495	0.599

Table 5: Financial and non financial analysis by project manager characteristics

This table shows the results of multivariate analysis, by logit model, between the likelihood of analyzing each of the dimensions of the project evaluation and the characteristics of the project manager. In addition to the coefficient of the variable is presented in brackets, the standard deviation associated to it. ***, ** And * show the existence of statistical significance at 1%, 5% and 10% respectively. (N = 83)

	Finance	Strategic	technical	Commercial	Political	Social	Environmental	Organizational	Human Resource	Project Manager
C	0.543 (0.252)	4.418 (1.052)	0.968 (0.456)	-2.402 (-1.313)	-2.877 * (-1.779)	-1.017 (-0.653)	-2.934 * (-1.733)	3.189 * (1.907)	2.141 (1.190)	-2.114 (-1.294)
Degree	1.340 (1.482)	0.653 (0.393)	-0.658 (-0.654)	1.201 (1.572)	0.563 (0.811)	-0.597 (-0.868)	1.764 ** (2.428)	0.047 (0.066)	0.668 (0.864)	0.723 (1.014)
Age	-0.009 (-0.226)	-0.039 (-0.451)	0.057 (1.327)	0.061 (1.643)	0.062 ** (1.969)	0.024 (0.766)	0.048 (1.455)	-0.054 * (-1.677)	-0.024 (-0.702)	0.064 * (1.955)
Position in the Company	1.441 * (-1.713)	-0.984 (-0.756)	-1.454 ** (-2.009)	0.109 (0.185)	-0.498 (-1.044)	-0.304 (-0.630)	0.729 (1.346)	0.025 (0.049)	-0.298 (-0.519)	-1.249 ** (-2.486)
Experience	-0.938 (-1.164)	41.851 (0.000)	-1.483 * (-1.839)	-0.323 (-0.521)	-0.279 (-0.529)	-0.349 (-0.659)	-0.564 (-1.002)	-0.578 (-1.052)	-1.457 ** (-2.206)	-0.129 (-0.240)
Fixed reward	1.319 * (-1.825)	-0.322 (-0.210)	1.007 (1.341)	0.408 (0.692)	-0.331 (-0.680)	0.711 (1.424)	0.146 (0.281)	0.150 (0.293)	0.802 (1.392)	-0.621 (-1.177)
McFadden R-squared	0.136	0.225	0.181	0.061	0.049	0.039	0.077	0.072	0.157	0.104
LR statistic (5 df)	9.787	5.805	13.047	5.262	5.630	4.404	8.233	7.803	15.403	11.733
Probability(LR stat)	0.081	0.326	0.023	0.385	0.344	0.493	0.1438	0.167	0.009	0.039

Table 6: Financial and non financial analysis influence the perception of success

1st International Conference on Project Economic Evaluation
ICOPEV'2011, Guimarães, Portugal

This table presents the results of multivariate analysis, by OLS model, between the perceived success of the project and the financial and non financial analyses. Panel A analyzes the influence of doing each analysis (Source Panel A: Moutinho and Lopes, 2010). Panel B analyzes the influence of the importance attributed to each areas of analysis in project evaluation. Panel C shows the results of the influence of consideration of a factor index, which is constructed for each area (constructed by assigning one point for each item / factor considered in the evaluation). This Panel analyze the influence of this index. In addition to the coefficient of the variable is presented, among parenthesis, the standard deviation associated to it. ***, ** And * show the existence of statistical significance at 1%, 5% and 10% respectively.

	<i>Panel A</i>	<i>Panel B</i>	<i>Panel C</i>
C	5.366 *** (0,396)	3,261 *** (0,714)	5,458 *** (0,324)
Financial Analysis	0.127 (0,319)	0,634 *** (0,135)	0,050 * (0,025)
Strategic Analysis	0.756 ** (0,316)	0,052 (0,145)	0,057 ** (0,027)
Technical Analysis	-0.298 (0,32)	0,135 (0,121)	0,018 (0,027)
Commercial Analysis	-0.004 (0,241)	0,213 * (0,115)	-0,022 (0,017)
Political Analysis	0.453 * (0,257)	-0,149 (0,109)	-0,005 (0,018)
Social Analysis	-1.047 *** (0,309)	-0,223* (0,12)	-0,009 (0,013)
Environmental Analysis	0.394 (0,246)	0,079 (0,102)	0,007 (0,015)
Organizational Analysis	-1.035 *** (0,197)	-0,058 (0,172)	-0,041 *** (0,01)
Human Resources Analysis	0.818 *** (0,245)	-0,007 (0,161)	0,011 (0,011)
Project Manager Analysis	-0.021 (0,196)	-0,037 (0,134)	-0,008 (0,01)
R-squared	25,82%	28,77%	20,88%
Adjusted R-squared	17,10%	20,39%	11,57%
F-statistic	2,959	3,433	2,243
Prob(F-statistic)	0,003	0,0008	0,022

Table 7: Critical success factor, by area of analysis

This table presents the results of the regressions, not reported, among the project's success and the factors relating to each analysis, by OLS. In this table are only indicated statistically significant variables to 10%.

<i>Painel A</i>	<i>Painel B</i>	<i>Painel C</i>	<i>Painel D</i>
<i>In project evaluation, the success of the project tends to be greater as more importance is assigned to:</i>	<i>In project evaluation, the project success tends to be greater when are adopted the following procedures:</i>	<i>In project evaluation, the success of the project tends to be smaller as more importance is assigned to:</i>	<i>In project evaluation, the project success tends to be smaller when are adopted the following procedures:</i>
<u><i>Financial Aspects</i></u>			
Accounting Rate of Return		Index Rate	
Critical Point Analysis			
<u><i>Strategic Aspects</i></u>			
Contribution to the company's strategic goals			
<u><i>Technical Aspects</i></u>			
	Verifying impact of technical changes		Not overlapping stages
	Sharing risk with partners		Technical and technological outsourcing
<u><i>Commercial Aspects</i></u>			
	Definition of a promotion policy consistent with the goals	Placement policy	
<u><i>Political Aspects</i></u>			
		Micro and macroeconomic policy	
<u><i>Social Aspects</i></u>			
Adopting a policy for social issues		Analysing the social consequences in similar projects	
Need for the cretion of employment and/or housing		Effects on the wealth of the population	
<u><i>Environmental Aspects</i></u>			
Penalties for environmental damages	Using technology compatible with environmental care	State's environmental control	Elaborating studies of environmental impact Continuously analysing environmental effets Using the knowledge of the local community
<u><i>Organizational Aspects</i></u>			
Cooperation beetween functional areas	There are a need to create partnerships	Permanently changing organizational structure	Adopting a project structure, independent structure from the company
Many hierarchic levels (vertical structure)	Adopting a matrix structure	Communication oriented to outside of the project	Elaborating training about the information system
Centralized decision-making	Project as part of the functional structure		Coordination of information flows
Activities coordinated informally	Constitution of work teams from various areas		Sharing information between membres of project
Centralised communications system	Analysis of partners' operational capacity		Analysis of partners' past performance
Flexible information system			Analysis of partners' financial capacity
Communication oriented only towards members of the project			
<u><i>Human Resources Aspects</i></u>			
Permanent interaction between members of teams	Selecting team workers	Ability to work autonomously	Performance evaluation considering the importance to the last stage
	Reward based on tenure	Future perspectives of working for company	Performance evaluation considering dedication/responsability
<u><i>Project Manager Aspects</i></u>			
Ambition		Technical skills	Motivation of employees and promotion of team spirit
Creativity	Analysis of problems and identification of viable solutions	Leadership skills	Definition and evaluation of priorities
		Ability to motivate	

Table 8: Factors influencing the success of projects

This table shows the results of multivariate analysis, by OLS, between the perception of success of the project and analysis of each of the characteristics of the company, the design, management and the manager. Panel A presents the characteristics of the company. Panel B shows the characteristics of the project. Panel C shows the characteristics of administration. Panel D shows the characteristics of the project manager. In addition to the coefficient of the variable is presented in brackets, the standard deviation associated to it. ***, ** And * show the existence of statistical significance at 1%, 5% and 10% respectively.

<i>Panel A</i>		<i>Panel B</i>		<i>Panel C</i>		<i>Panel D</i>	
C	3.475 *	C	2.912 **	C	5.872 ***	C	5.129 ***
	(1.690)		(2.203)		(8.166)		(6.208)
Ln (sales)	0.048	Substituição	0.330	Licenciatura	0.421	Licenciatura	0.894 **
	(0.422)		(0.884)		(1.462)		(2.461)
Ln (Debt)	0.075	Modernização	0.378	Idade	-0.011	Idade	0.004
	(0.797)		(1.079)		(-0.816)		(0.279)
Public	-0.213	Expansão	0.307	Tempo no Cargo	0.035 **	Cargo na Empresa	0.257
	(-0.448)		(0.821)		(2.076)		(1.012)
Payout	0.497 *	Duração	-0.014	Capital	-0.172	Experiência	-0.018
	(1.964)		(-1.662)		(-0.705)		(-0.065)
Emp. Privada Nacional	0.227	Dimensão	0.202 **			Compensação Fixa	-0.539 **
	(0.873)		(2.191)				(-2.061)
Comércio por Grosso e	0.054	Dimensão Relativa	-0.451				
	(0.149)		(-1.406)				
Indústria Transformad	-0.200						
	(-0.592)						
Transporte/Energia	-0.350						
	(-0.815)						
R-squared	0.103		0.085171		0.057902		0.113386
Adjusted R-squared	0.0107		0.008936		0.011946		0.055814
F-statistic	1.115		1.117211		1.259946		1.969455
Prob(F-statistic)	0.362		0.360991		0.292470		0.092613

Table 9: Importance of financial and non-financial analysis, by company industry

Table 10: Importance of financial and non financial analysis, by type of project

This table shows the data of the sample to manufacturing industries (Panel A), commerce (Panel B) and transport and energy (Panel C). Panel A.1, B.1 and C.1 show the number of times that each area of analysis was carried out. Panel A.2, B.2 and C.2 show the importance (on a scale of 1 to 5) of each area of analysis in the evaluation of projects, and the percentage of companies considering each area of analysis important and very important to project appraisal. Panel A.3 and B.3 present the results, by OLS model, of the influence of doing each analysis in the perception of project success. Panel C3 is not displayed because the data does not permit their calculation. Panel A.4, B.4 and C.4 presents the results, by OLS model, of the influence of the importance attributed to each area of analysis in the perception of project success. Panel A.5, B.5 and C.5 presents the results, by OLS model, of the influence of index factors consideration (to each area assessed, the index is constructed by assigning one point each item / factor considered in the assessment) in the perception of success of the project. In addition to the coefficient of the variable is presented, among parenthesis, the standard deviation associated to it. ***, ** and * show the existence of statistical significance at 1%, 5% and 10% respectively.

	Panel A: Manufacturing (N=37)							Panel B: Commercial (N=24)							Panel C: Transport / Energy (N=16)						
	Panel A.1		Panel A.2		Panel A.3	Panel A.4	Panel A.5	Panel B.1		Panel B.2		Panel B.3	Panel B.4	Panel A.3	Panel C.1		Panel C.2		Panel C.4	Panel C.5	
Analysis																					
C					4,541 *** (1,525)	3,591 ** (2,699)	4,669 *** (0,66)					6,578 *** (1,108)	3,358 (1,934)	7,496 *** (1,647)					8,675 * (3,511)	2,285 (1,370)	
Strategic	35	94,59%	3,59	97,30%	1,309 (0,185)	0,174 (0,338)	0,099 * (0,052)	23	95,83%	3,50	87,50%	-0,772 (1,267)	-0,273 (0,227)	-0,105 (0,136)	16	100,00%	3,50	93,75%	-0,244 (0,328)	-0,034 (0,124)	
Technical	35	94,59%	3,38	86,49%	-0,257 (1,073)	0,124 (0,291)	0,073 (0,058)	11	45,83%	2,92	75,00%	-0,378 (0,576)	-0,112 (0,167)	0,127 (0,090)	16	100,00%	3,31	93,75%	-0,696 (0,832)	0,383 ** (0,100)	
Commerce	25	67,57%	2,62	64,86%	-0,254 (0,599)	0,055 (0,387)	-0,002 (0,021)	19	79,17%	3,38	87,50%	-0,243 (0,534)	0,19 (0,399)	-0,059 (0,041)	15	93,75%	3,00	81,25%	0,075 (0,141)	-0,041 (0,041)	
Political	16	43,24%	1,30	10,81%	0,272 (,599)	-0,414 * (0,204)	0,019 (0,081)	3	12,50%	1,50	25,00%	0,486 (0,799)	-0,083 (0,173)	-0,174 (0,101)	14	87,50%	2,00	50,00%	-0,158 (0,372)	0,044 (0,075)	
Finance	34	91,89%	2,89	70,27%	1,024 (0,962)	0,492 ** (0,227)	-0,005 (0,045)	18	75,00%	3,13	83,33%	-0,749 (0,0551)	0,624 ** (0,241)	0,11 (0,067)	14	87,50%	2,81	75,00%	1,861 *** (0,409)	0,329 *** (0,074)	
Social	13	35,14%	1,43	21,62%	-1,213 * (0,662)	0,200 (0,217)	-0,029 (0,042)	7	29,17%	2,04	45,83%	-0,991 (1,029)	-0,419 (0,315)	0,001 (0,069)	13	81,25%	2,38	50,00%	-1,088 (0,847)	-0,096 (0,060)	
Environmental	27	72,97%	2,35	54,05%	0,751 (0,542)	-0,207 (0,184)	0,009 (0,026)	11	45,83%	1,92	50,00%	1,414 ** (0,647)	0,285 (0,282)	0,064 (0,082)	10	62,50%	2,69	68,75%	-0,471 (0,325)	-0,017 (0,020)	
Organizational	24	64,86%	2,49	62,16%	-0,675 (0,445)	0,051 (0,319)	-0,057 ** (0,024)	13	54,17%	2,75	70,83%	-0,029 (0,657)	0,069 (0,354)	0,010 (0,042)	11	68,75%	2,31	43,75%	-1,998 ** (0,617)	-0,003 (0,0489)	
Human Resource	27	72,97%	2,32	59,46%	-0,484 (0,533)	-0,333 (0,355)	-0,002 (0,028)	17	70,83%	2,71	66,67%	1,837 ** (0,666)	0,284 (0,278)	-0,034 (0,050)	11	68,75%	2,06	37,50%	2,099 * (0,822)	-0,108 ** (0,0399)	
Project Manager	17	45,95%	2,73	62,16%	0,179 (0,559)	0,393 (0,271)	-0,001 (0,012)	12	50,00%	2,79	70,83%	-0,592 (0,444)	0,348 (0,284)	-0,039 (0,026)	11	68,75%	2,63	68,75%	-0,399 (0,261)	0,013 (0,026)	
R-squared					29,99%	45,96%	40,81%					67,2%	59,43%	49,50%					95,39%	89,51%	
Adjusted R-squared					3,07%	25,17%	18,05%					41,97%	28,23%	10,60%					86,17%	68,53%	
F-statistic					1,114	2,21	1,79					2,664	1,904	1,27					10,353	4,266	
Prob(F-statistic)					0,388	0,05	0,112					0,05	0,137	0,33					0,00935	0,061	

This table shows the data of the sample for expansion projects (Panel A), modernization projects (Panel B) and replacement projects (Panel C). Panel A.1, B.1 and C.1 show the number of times that each area of analysis was carried out. Panel A.2, B.2 and C.2 show the importance (on a scale of 1 to 5) of each area of analysis in the evaluation of projects, and the percentage of companies considering each area of analysis important and very important to project appraisal. Panel B.3 and C.3 presents the results, by OLS model, of the influence of doing each analysis in the perception of project project. Panel A3 is not presented because the data do not permit their calculation. Panel A.4, B.4 and C.4 presents the results, by OLS model, of the influence of the importance attributed to each area of analysis in the perception of project success. Panel A.5, B.5 and C.5 presents the results, by OLS model, of the influence of index factors consideration (to each area assessed, the index is constructed by assigning one point each item / factor considered in the assessment) in the perception of success of the project. In addition to the coefficient of the variable is presented, among paraentesis, the standard deviation associated to it. ***, ** and * show the existence of statistical significance at 1%, 5% and 10% respectively.

	Panel A: Expansion Projects (N=47)					Panel B: Modernization Projects (N=38)					Panel C: Replacement Projects (N=16)									
	Panel A.1		Panel A.2		Panel A.4	Panel A.5	Panel B.1		Panel B.2		Panel B.3	Panel B.4	Panel A.3	Panel C.1		Panel C.2		Panel C.3	Panel C.4	Panel C.5
Analysis																				
C					4,270 *** (0,948)	6,026 *** (0,781)					4,729 *** (0,940)	4,895 *** (1,743)	5,022 *** (0,525)					7,489 ** (2,452)	1,414 (6,983)	5,448 *** (1,106)
Strategic	47	100,00%	3,70	97,87%	-0,132 (0,259)	0,011 (0,082)	35	92,11%	3,16	86,84%	0,441 (0,631)	-0,056 (0,216)	0,058 (0,046)	14	87,50%	3,13	87,50%	-1,127 (2,814)	-0,574 (0,768)	0,003 (0,142)
Technical	36	76,60%	3,06	80,85%	-0,036 (0,161)	0,031 (0,027)	33	86,84%	3,39	92,11%	0,112 (0,610)	0,0246 (0,325)	0,031 (0,046)	14	87,50%	3,75	100,00%	0,414 (3,789)	1,220 (1,270)	0,063 (0,078)
Commerce	40	85,11%	3,13	85,11%	0,071 (0,167)	-0,060 ** (0,024)	29	76,32%	2,84	71,05%	0,616 (0,546)	0,066 (0,154)	0,023 (0,024)	11	68,75%	2,44	56,25%	0,468 (1,092)	0,169 (0,229)	0,065 (0,041)
Political	18	38,30%	1,34	23,40%	0,008 (0,107)	0,034 (0,043)	17	44,74%	1,45	15,79%	-0,034 (0,453)	-0,286 (0,222)	-0,026 (0,019)	8	50,00%	1,38	12,50%	1,319 (1,709)	0,146 (0,446)	0,001 (0,241)
Finance	40	85,11%	2,89	76,60%	0,949 *** (0,221)	0,105 ** (0,044)	29	76,32%	3,00	71,05%	0,362 (0,537)	0,232 * (0,135)	0,009 (0,046)	13	81,25%	3,19	81,25%	-1,361 (1,522)	0,435 (0,698)	-0,009 (0,230)
Social	21	44,68%	1,96	42,55%	-0,207 (0,174)	-0,027 (0,023)	12	31,58%	1,50	21,05%	0,167 (0,307)	0,228 (0,226)	0,001 (0,012)	4	25,00%	1,56	18,75%	-0,952 (1,109)	-0,281 (0,675)	-0,063 (0,172)
Environmental	30	63,83%	2,43	61,70%	-0,138 (0,216)	-0,021 (0,022)	21	55,26%	2,03	47,37%	-0,153 (0,313)	0,028 (0,162)	0,018 (0,016)	10	62,50%	2,31	50,00%	-0,202 (1,368)	0,236 (0,305)	0,063 (0,045)
Organizational	28	59,57%	2,49	59,57%	-0,214 (0,258)	-0,062 *** (0,013)	24	63,16%	2,47	57,89%	-0,352 (0,455)	-0,378 (0,309)	-0,011 (0,015)	9	56,25%	2,63	68,75%	-0,648 (1,404)	1,007 (0,651)	-0,030 (0,040)
Human Resource	32	68,09%	2,30	48,94%	0,149 (0,235)	0,043 *** (0,015)	26	68,42%	2,26	52,63%	0,286 (0,379)	0,056 (0,297)	-0,013 (0,019)	12	75,00%	2,56	68,75%	0,372 (3,283)	-1,351 (0,763)	-0,033 (0,053)
Project Manager	26	55,32%	2,74	76,60%	0,067 (0,174)	-0,009 (0,012)	24	63,16%	2,61	65,79%	0,050 (0,472)	0,127 (0,236)	-0,005 (0,017)	7	43,75%	2,81	62,50%	-0,574 (1,246)	0,204 (0,733)	-0,016 (0,055)
R-squared					36,2%	49,80%					29,38%	43,2%	23,21%					68,21%	68,35%	66,91%
Adjusted R-squared					18,5%	35,85%					3,2%	22,23%	5,21%					4,65%	5,05%	0,75%
F-statistic					2,045	3,571					1,123	2,057	0,8165					1,073	1,079	1,0113
Prob(F-statistic)					0,056	0,0022					0,381	0,066	0,615					0,499	0,496	0,529

Table 11: Importance of financial analysis and non-financial, by project size

This table shows the data of the sample for large-scale projects (Panel A) and small-scale projects (Panel B). Panel A.1 and B.1 show the number of times that each area of analysis was carried out. Panel A.2 and B.2 show the importance (on a scale of 1 to 5) of each area of analysis in the evaluation of projects, and the percentage of companies considering each area of analysis important and very important to project appraisal. Panel B.3 shows the results, by OLS model, of the influence of doing each analysis in the perception of project success. Panel A3 is not presented because the data do not permit their calculation. Panel A.4 and B.4 present the results, by OLS model, of the influence of the importance attributed to each area of analysis in the perception of project success. Panel A.5 and B.5 shows the results, by OLS model, of the influence of index factors consideration (to each area assessed, the index is constructed by assigning one point for each item / factor considered in the assessment) in the perception of success of the project. In addition to the coefficient of the variable is presented, among parenthesis, the standard deviation associated to it. ***, ** and * show the existence of statistical significance at 1%, 5% and 10% respectively.

Panel A: Large-scales Projects (N=29)						
	<i>Panel A.1</i>		<i>Panel A.2</i>	<i>Panel A.3</i>	<i>Panel A.4</i>	<i>Panel A.5</i>
C					4,168 ** (1,847)	2,979 *** (0,947)
Strategic Analysis	29	100,00%	3,52	93,10%	-0,165 (0,384)	0,117 (0,078)
Technical Analysis	29	100,00%	3,59	93,10%	0,412 (0,406)	0,187 ** (0,071)
Commercial Analysis	24	82,76%	2,83	79,31%	-0,163 (0,333)	-0,049 ** (0,020)
Political Analysis	20	68,97%	1,93	34,48%	-0,153 (0,190)	-0,011 (0,026)
Finance Analysis	25	86,21%	3,03	82,76%	0,699 * (0,382)	0,069 (0,055)
Social Analysis	16	55,17%	2,03	24,14%	0,387 (0,347)	-0,031 (0,032)
Environmental Analysis	25	86,21%	2,90	72,41%	-0,690 (0,450)	-0,003 (0,030)
Organizational Analysis	17	58,62%	2,48	62,07%	-0,089 (0,707)	-0,096 *** (0,019)
Human Resources Analysis	22	75,86%	2,45	58,62%	-0,54 (0,799)	0,038 * (0,021)
Project Manager Analysis	16	55,17%	2,93	79,31%	0,364 (0,556)	0,032 * (0,016)
R-squared					42,90%	76,83%
Adjusted R-squared					11,18%	63,96%
F-statistic					1,352	5,9705
Prob(F-statistic)					0,276	0,00054
Panel B: Small-scale Projects (N=55)						
<i>Analysis</i>	<i>Panel B.1</i>		<i>Panel B.2</i>	<i>Panel B.3</i>	<i>Panel B.4</i>	<i>Panel B.5</i>
C				5,892 *** (0,627)	3,272 ** (1,436)	6,179 *** (0,548)
Strategic	51	92,73%	3,45	90,91%	0,801 * (0,463)	0,022 (0,051)
Technical	43	78,18%	3,13	81,82%	-0,046 (0,440)	-0,011 (0,046)
Commercial	42	76,36%	2,87	70,91%	0,223 (0,541)	-0,054 (0,038)
Political	15	27,27%	1,09	10,91%	1,388 *** (0,458)	0,104 (0,138)
Finance	45	81,82%	2,80	65,45%	-0,411 (0,666)	0,089 (0,061)
Social	16	29,09%	1,49	29,09%	-2,144 *** (0,514)	-0,227 ** (0,107)
Environmental	29	52,73%	1,82	40,00%	0,400 (0,332)	0,056 (0,039)
Organizational	33	60,00%	2,33	50,91%	-0,922 ** (0,377)	-0,046 ** (0,019)
Human Resources	36	65,45%	2,11	45,45%	0,195 (0,381)	0,006 (0,023)
Project Manager	29	52,73%	2,55	60,00%	-0,465 (0,307)	-0,009 (0,013)
R-squared					61,68%	41,27%
Adjusted R-squared					46,35%	17,78%
F-statistic					4,024	1,757
Prob(F-statistic)					0,0022	0,122

TABLE 12: Importance of financial and non-financial analysis, by project duration

This table shows the data of the sample for short-term projects (Panel A) and long-term projects (Panel B). Panel A.1 and B.1 show the number of times that each area of analysis was carried out. Panel A.2 and B.2 show the importance (on a scale of 1 to 5) of each area of analysis in the evaluation of projects, and the percentage of companies considering each area of analysis important and very important to project appraisal. Panel A.3 shows the results, by OLS model, of the influence of doing each analysis in the perception of project success. Panel B.3 is not displayed because the data does not permit their calculation. Panel A.4 and B.4 present the results, by OLS model, of the influence of the importance attributed to each area of analysis in the perception of project success. Panel A.5 and B.5 shows the results, by OLS model, of the influence of index factors consideration (to each area assessed, the index is constructed by assigning one point for each item / factor considered in the assessment) in the perception of success of the project. In addition to the coefficient of the variable is presented, among parenthesis, the standard deviation associated to it. ***, ** and * show the existence of statistical significance at 1%, 5% and 10% respectively.

		Panel A: Short-term Projects (N=53)					
		Panel A.1		Panel A.2	Panel A.3	Panel A.4	Panel A.5
C					5,662 *** (0,477)	3,258 *** (1,147)	6,349 *** (0,367)
Strategic Analysis		51	94,44%	3,43	90,74% 0,230 (0,453)	0,265 (0,223)	-0,001 (0,029)
Technical Analysis		40	74,07%	3,24	85,19% -0,094 (0,346)	0,087 (00,127)	0,030 (0,032)
Commercial Analysis		43	79,63%	2,96	77,78% -0,367 (0,364)	0,160 (0,159)	-0,044 ** (0,021)
Political Analysis		14	25,93%	1,09	14,81% 0,817 * (0,418)	-0,043 (0,175)	0,034 (0,034)
Finance Analysis		44	81,48%	2,98	70,37% 0,729 (0,597)	0,497 *** (0,173)	0,044 (0,027)
Social Analysis		18	33,33%	1,56	31,48% -1,348 *** (0,467)	-0,555 ** (0,207)	-0,024 (0,019)
Environmental Analysis		31	57,41%	2,00	44,44% 0,643 ** (0,316)	0,325 ** (0,151)	0,039 * (0,020)
Organizational Analysis		29	53,70%	2,24	48,15% -0,627 ** (0,282)	0,014 (0,190)	-0,037 *** (0,010)
Human Resources Analysis		35	64,81%	2,11	40,74% 0,236 (0,317)	0,182 (0,164)	0,012 (0,014)
Project Manager Analysis		32	59,26%	2,61	68,52% 0,083 (0,300)	-0,171 (0,151)	-0,022* (0,013)
R-squared					40,04%	0,43,86%	40,97%
Adjusted R-squared					25,77%	30,50%	26,91%
F-statistic					2,805	3,282	2,9153
Prob(F-statistic)					0,0093	0,0032	0,0073
		Panel B: Long-term Projects(N=35)					
Analysis		Panel B.1		Panel B.2	Panel B.3	Panel B.4	Panel B.5
C						4,466 ** (1,643)	3,926 *** (0,615)
Strategic		35	100,00%	3,49	91,43% 0,085 (0,208)	0,085 (0,208)	0,208 *** (0,050)
Technical		33	94,29%	3,46	91,43% -0,285 (0,437)	-0,285 (0,437)	-0,015 (0,064)
Commercial		26	74,29%	2,83	71,43% 0,133 (0,232)	0,133 (0,232)	-0,002 (0,021)
Political		23	65,71%	1,94	22,86% -0,086 (0,176)	-0,086 (0,176)	0,028 (0,024)
Finance		32	91,43%	2,91	77,14% 0,467 ** (0,215)	0,467 ** (0,215)	-0,020 (0,064)
Social		15	42,86%	2,00	25,71% 0,149 (0,302)	0,149 (0,302)	-0,003 (0,027)
Environmental		24	68,57%	2,60	65,71% -0,067 (0,285)	-0,067 (0,285)	-0,035 (0,0266)
Organizational		25	71,43%	2,66	65,71% 0,083 (0,519)	0,083 (0,519)	-0,005 * (0,030)
Human Resources		26	74,29%	2,60	71,43% -0,413 (0,395)	-0,413 (0,395)	0,005 (0,017)
Project Manager		16	45,71%	2,89	71,43% 0,352 (0,245)	0,352 (0,245)	0,024 (0,017)
R-squared						29,00%	52,80%
Adjusted R-squared						5,75%	33,13%
F-statistic						0,980	2,685
Prob(F-statistic)						0,485	0,023

THE COST/BENEFIT ANALYSIS IN THE SCOPE OF NEOCLASSICAL ECONOMICS

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ABSTRACT

The age of the globalization is inherently the age of the Neo-Liberalism, and it is therefore normal that Neoclassical theory dominates economics nowadays. On another strand, Cost/Benefit Analysis (CBA) is also critical for economics. A first main conceptualization of CBA was made by Alfred Marshall in the early 20th century. The CBA estimation measures the equivalent value of the benefits versus costs to the community of a wide range of projects, from highways to hospitals. "If the benefits to whomever they accrue [be] in excess of the estimated costs" then a given project will be worthwhile under CBA (US Congress, 1936, 1939).

Using a CBA approach, this paper examines whether the interventions of the monetary authorities in the financial sector were beneficial for the economy, and for business overall. Widely criticised, the authorities' "socialisation of the losses" resulted in higher budgetary deficits, forcing governments to hike taxes and therefore increasing costs for businesses, reducing competitiveness. Nevertheless, a non-intervention would result in a massive increase of business failures and in a major surge in unemployment, likely leading to a possible depression that would take years to tackle. Therefore, this paper contributes for the discussion of the desirable role of governmental and monetary authorities in the economic activity.

INTRODUCTION

The age of the globalization is inherently the age of the Neo-Liberalism, and it is therefore normal that Neoclassical theory dominates economics nowadays. Neo-Liberalism has its routes in early optimistic economic theories, such as in Adam Smith's classical Invisible Hand (1759, 1776), although the *laissez faire* origins can be traced even earlier (vid. Keynes, 1926, for remarks on its origins). In opposition

to Keynesians, neoliberals argue that governments underperform the private sector when running businesses, being governmental intervention regarded as undesirable, since it is believed that private activity is more efficient in its absence. As theorised by Friedman (1962) and his disciples, monetary policy, i.e. the control of money supply, should be used in order to balance the economic activity with the economic cycles; a view in opposition to Keynesianism which relies primarily in the budgetary policy, namely in the use of governmental deficits to tackle economic downturns and in the use of taxes to ensure social welfare.

The current financial crisis revealed the consequences of the lack of adequate regulation, proving the inability of economic agents and markets to self-regulate (is not self-regulation an utopia anyway?). Market participants are regarded as *homo economicus*, but their essence can never be something else than the one of a typical human being. This means that under specific circumstances market's rationality is likely to be overruled by basic extreme emotions, such as panic or euphoria. Under a severe crisis, even a sophisticated economic agent can be found lost as a child in the forest looking for protection, provided there is a deep involvement in the business.

Therefore, recent events suggest that liberalism failed also, as private sector did not perform as well as expected, and the benefits from the Invisible Hand to individual societies in Western Countries seemed to be suddenly diluted by several factors, such as the delocalisation incentivised by globalization. The current actions to tackle the crisis also suggest a return to socialism. However, they are diffuse as they intend to stop the bleeding, and not to cure the patient. Indeed, the governmental interventions on the financial system, which included nationalisations, capital purchases and other bailout schemes, were simply critical measures to avoid the collapse of the financial system, due to systemic risk. In fact, the whole system was on the edge of collapsing in September 2008. Following Freddie Mac, Fannie Mae, and AIG's bailouts, the bankruptcy of Lehman Brothers, on the 15th September, was a milestone for the credit markets. It was the biggest ever

bankruptcy in the USA, more than \$600 bn in assets, ten times Enron's size. Credit, the blood of the system, simply stopped to flow.

The actions taken so far can be labelled as *socialism for the wealthiest*, as they will benefit society indirectly only. However, due to an extreme low confidence in the financial industry, credit continues to defrost very slowly and such *benefits* are still to be felt. No substantial changes in the status quo are therefore foreseen. It is simply a question of capital conservation, by the means of limitation of wealth losses, with the purpose to maintain capitalism alive, with little impact on the *real* economy.

If the banking industry and neoliberal views played a major role in the occurrence of this crisis it is therefore appropriate to make them the ultimate scapegoats? Certainly so, particularly for politicians. It is important to recall that the current financial crisis - made in the USA, just like the Great Depression - was preceded by the subprime crisis, which is still to be fixed, and by massive governmental budget deficits, often resulting from substantially failed policies, namely the ones related to international affairs. But there are other reasons, including globalization itself. It is true that the banking industry was conceivably one of the most powerful lobbies in recent years, influencing politicians in charge, which commonly lack economic education. Easy and cheap credit favoured nominal profits to financial institutions, but enhanced also the wellbeing of families providing incentives to buy more houses, and new cars, even if they could not afford to. This has benefited politicians, since easing monetary policy meant a faster recovery from the early 2000's economic crisis and a faster economic growth afterwards, resulting in more income, more taxes and additional governmental spending possibilities, i.e. more happy voters, and additional *bonus* to politicians, CEO's and partners. The result: an almost collapse of a model and a huge bill that needs to be partially paid immediately, for the good sake of future generations which are already so much in debt. What is the Cost/Benefit Analysis (CBA) that can be made of such actions?

A first main raw conceptualization of the Cost/Benefit Analysis (CBA) can be traced back to Alfred Marshall in the early 20th century (vid. e.g. 1919), even if a earlier source of inspiration could be attributed to Jules Dupuit (1844, 1848). The CBA estimation measures the equivalent value of the benefits versus costs to the community of a wide range of projects, from highways to hospitals. For example, in the United States (US), while actions related to water resources issues were being discussed, the approved body text of the 1936 and 1939 Flood Control Act's refers that if the "benefits to whomever they accrue [be] in excess of the estimated costs" then a given project will be worthwhile under CBA (US Congress, 1939, op. cit. Gramlich, 1981: 7. Vid. also Mishan and Quah, 2007).

Using a CBA approach, this paper examines whether the interventions of the monetary authorities in the financial sector were beneficial for the economy, and for business overall. Widely criticised, the authorities' "socialisation of the losses" resulted in higher budgetary deficits, forcing governments to hike taxes and therefore increasing costs for businesses, reducing competitiveness. Nevertheless, a non-intervention would result in a massive increase of business failures and in a major surge in unemployment, likely leading to a possible depression that would take years to tackle. Therefore, this paper contributes for the discussion of the desirable role of governmental and monetary authorities in the economic activity.

FROM MERCANTILISM TO MODERN NEOCLASSICAL ECONOMICS

The main idea of mercantilism was that money, and not production, was the source of wealth. According to Mings and Marlin (2000: 435) mercantilism and mercantilists could be regarded as: "Mercantilists – those advocated mercantilism, a doctrine that dominated that policies in many countries from the sixteenth to the eighteenth centuries. It held that exports should be maximized and imports minimized to generate inflows of gold and those exports of machinery and technology should be prohibited to prevent competition from foreign producers."

Mercantilist economics was supported by most Western kingdoms in pre-modern era. When a country ran this kind of economy and politics it could accumulate more gold and silver, that would allow the country leaders to increase wealth. Indeed, the goal of mercantilism was to strengthen a country's power and its richness as well. Property owners had the opportunity to get all actions with other goods and services. This was a somewhat revolutionary shift in terms of long-term approach to assets and sources as, for many centuries, including the entire Middle Age, agriculture was considered the only source of wealth (vid. e.g. Sloman, 2000).

Adam Smith, the classical political economy representative, with his work "Wealth of Nations" introduced a theory of economics in 1776. As Mings and Marlin (2000: 115) refer, Adam Smith "was arguing in opposition to the system of mercantilism under which the government exercised a great deal of control over economic life. The government regulated production and trade with the objective of bringing gold and silver into the coffers of the state. Smith contended that nation's real wealth would be maximized by allowing individuals to make economic decisions based on the forces of marketplace, unhindered by government regulations. He maintained that in pursuing their own self-interest, people would be guided by an invisible hand to maximize their personal contribution to the economy."

Other economists would follow soon after, further contributing to the development of the economic theory, such as Ricardo, Stuart Mill, or Malthus, which can not be examined in this paper for obvious reasons.

As the Industrial Revolution move forward and spread across economies, the mass production powered by the development of the engine, increased conflicts between labour and capital. Karl Marx, representing the interests of workers, returning to the classic argument argued that wealth is created by the labour, so all wealth should go back to the labour. Upon Hegel's dialectic materialism, Marx believed that this type of convulsions would finish with Capitalism, leading Communism to victory (1848 with Engels, 1867).

However, so far history is not in favour of Marx and Engels. The Marxist economic experience under the form of Communism resulted catastrophic as proved by the Berlin's Wall fall and by the collapse of the USSR, revealing a large set of underperforming economies, at least when compared with Western countries that adopted capitalism.

It is also noteworthy to mention that new economic theories started to focus in other values than material, which is, after all, the key factor of analysis both for Marxism and Capitalism. Indeed, more recently, within other economic theories different tendencies can be recognised as being also important. They tend to replace the focus on economic history and other aspects by social and economic relationships. For example, national economic theory (not to be confounded with Keynesianism) believes that economic development depends not just on material factors, but also on spiritual factors, which vary among every country (vid. e.g. Petras and Trachte, 1979).

As both Communism and other alternative economic thoughts and theories failed to be dominant throughout time, only the most relevant economic theories will be examined in this paper.

Meanwhile, a "Marginal revolution" occurred, following a seminal paper from William Jevons (1862), which would have contributions from other economists, most notably from Léon Walras and Carl Menger. This strand would be enriched by later generations, including economists such as Alfred Marshall and the ones from the Austrian School.

The Marginal utility school stated that values and prices are determined by their marginal utility - the last unit (goods or facilities) which is required and proposed in the market. It has provided a great attention to the use of mathematics in economics, by expanding and formalising the concept of limits to mathematical formulas and graphs. Mathematical methods are examined and used in order to find functional relationships, aiming to find the conditions which produce the best economic performance. The concept of optimum is therefore introduced.

The 20th century development of economics was affected by the World Wars, economic crisis, and scientific and technical revolutions. Unsurprisingly, fresh new economic theories appeared.

As a result of the 1929 crash and the following Great Depression, a new economic model was needed. It was now the time of John Maynard Keynes, who argued that only governmental economic policies could reborn the sluggish economy of the US. The age of the regulation was starting, together with an increasing role of public expenditure.

Regulatory capitalism theory's essence is based in the growth of the nation role in the economy. It became very much popular. Indeed, Keynesianism became the economic paradigm of social welfare. However, this theory failed to ensure sustainability, as proved by the 1970's turbulence. The increasing role of the government in the economy resulted in significant inefficiencies, which became more visible with the 1973 oil crisis and the subsequent inflationary process, with an increase of unemployment and without any meaningful economic growth, a malaise phenomenon called stagflation.

For this theory, such evidence meant that its principles do not always necessarily contribute to avoid economic recession, and to prevent unemployment and inflation. A new economic model was needed, as Keynesianism could not provide solid answers to stagflation.

Then neoclassical economics started to strengthen. Neoclassical economics was first developed in the late-nineteenth century. This became opposed to the capitalism theory as defended by Keynes. It claimed that the nation role in the economy should not be increased. It should instead rely on self-regulatory mechanisms of the market, by recognising the limited role of the state.

From the beginning that modern neoclassical economics has become the most popular economics theory. However, this theory also faces widespread criticism, such as that neoclassical economics makes many unfounded and unrealistic assumptions that do not represent real situations, being often accused to rely too much in the importance of financial markets.

THE CONCEPT OF COST/BENEFIT ANALYSIS AND ITS USE IN ECONOMICS

The development of cost-benefit analysis has played an important role in economics. Due to the economic and social evolution, governments started to be required to demonstrate the amount of benefit resulting from proposed policies, but also together with consideration to the related costs.

This phenomenon was particularly visible in the US, being an example given earlier in this paper, the case of the 1939 Flood Control Act (US Congress, 1939). With the purpose to demonstrate and to justify the worthiness and profitability of a given project, government agencies

were increasingly using quantitative analysis of costs and benefits. In fact, in the 1930s the use of CBA was made compulsory in certain circumstances in the US (Mishan and Quah, 2007).

However, in the absence of a settled procedure analysis, often governmental agencies were creating their own procedures. Usually these procedures were unstructured and defective. Therefore, in late 1940s the US government decided to settle standards for cost-benefit analysis procedure (Mishan and Quah, 2007). Economists started adjusting economic concept to make analysis base more exhaustive, rational and based on theory, becoming a standard practice from the 1950s (Mishan and Quah, 2007).

For a more recent definition of CBA, one can give as an example the proposed definition of cost-benefit analysis by John Sloman (2000), who suggests that cost-benefit analysis may be defined as the identification, measurement and weighing-up of the costs and benefits of a project in order to decide whether or not it should go ahead. Cost-benefit analysis helps to examine whether investing in a proposed project is profitable. It means that this analysis is a meaningful tool for providing information to decision makers.

This technique may be used by governments, but also by private companies as well. Governments use this cost-benefit analysis technique to take decisions about approving or not the realization of relevant projects to society. The idea is that a project may be approved whenever costs are lower than the expected benefits for the society. If the costs outweigh benefits then the project should not be supported.

The main difference in cost-benefit analysis between private sector and governmental sector is that they identify costs and benefits in a different way. Private companies are more concerned about obtaining net profits, maximizing then society wellness differently than governments. In fact, for companies from the private sector what really matters are private monetary benefits and incurred costs, whose consideration focus, in other words, may be simply defined as “variables that affect net profit: receipts and expenditures” (Todaro and Smith, 2003: 688).

Differently from private firms, governments take into consideration not only the private analysis, more focused in financial aspects, but also non-monetary costs and benefits, such as the case of externalities or spillovers (e.g. traffic, noise, air pollution).

The cost-benefit analysis often considers four main steps: identification of essential costs and benefits; measurement of those costs and benefits; comparison between cost and benefit flows during the project period; and, finally, the project adoption. Boardman et al. (1996: 7), suggested a more comprehensive set of basic steps of CBA, as shown below in Table 1.

Table 1: Seven Basic Steps of a CBA

- | |
|---|
| 1. Determine which stakeholders will be included in the analysis |
| 2. Identify the alternative policies to be considered |
| 3. Identify the likely physical impacts and select the appropriate measurement indicators |
| 4. Predict the impacts over the life of the project |
| 5. Attach a dollar amount to all of the impacts |
| 6. Find the present value of the dollar amounts over time |
| 7. Add up the costs and benefits |
| 8. Perform a sensitivity analysis of the results |
| 9. Select the alternative with the largest net social benefits |

In resume, the main task of identification and measurement of costs and benefits is to recognize possible losses and gains, and to determine the output value of proposed project. When comparing costs and benefits, the present worth value of future gains and losses of the project must be evaluated and compared with the present value of the investment costs.

There are usually plenty of proposed projects and they are ranged by satisfaction of at least one of the free main criteria: ratio of the costs and benefits, the net present value and inner ratio of return. If a project has a cost-benefit ratio over one, a net present value bigger than zero, and an internal rate of return bigger than the market rating or any other socially admissible ratio of return, then, mostly, that project should be approved.

Independently of the fact that private companies and government put attention on different objectives while considering a project, the cost-benefit analysis in both cases has the same goal – effectiveness. It helps to evaluate whether the project is worth-while of being invested, allowing to probably choosing the right project among a diversity of different proposals, which often can be very large.

An example of Cost-Benefit Analysis usage

Nas (1996: 58-59), provides an interesting example of a CBA analysis, as shown in the illustration below.

<i>For illustration, consider a public project to improve the uncrowned shore of a small community by converting it into a public beach. The estimated cost of developing the beach is \$150,000, and the future maintenance and operating costs are expected to be \$15,000 annually. When completed, the beach will be provided free of charge to an estimated 15,000 individuals per year. Currently, 6,000 individuals each year enjoy the existing facilities that are available for a variety of recreational activities, such as swimming, camping, and sailing at several locations along the</i>

shore. These facilities are served by the nearby private businesses, who charge a fee of \$3 per visitor; the average cost is \$2.50, and average profit made by these businesses is \$0.50 per person.

To determine the feasibility of this project, the first step is to identify and calculate the net expected annual gains from its implementation. The annual benefit include two figures: (a) a gain of \$18,000 ($\$3 \times 6,000$) to the existing users, who will be able to use the parking facilities and services free of charge; and (b) a gain of \$13,500 ($0.50 \times (\$3 \times 9,000)$) to the new users roughly estimated by the projected number of new visitors multiplied by the fee that they would have paid had there be a charge. The annual costs will also include two items: (a) a loss of \$3,000 ($(\$3 - \$2.50) \times 6,000$) to the existing businesses because of the foregone profit of \$0.50 per visitor, and (b) a loss of \$15,000 to the taxpayers since tax money will be used for maintenance and operation.

Next, the yearly net benefits of \$13,500 are calculated by subtracting the total annual losses of \$18,000 ($\$3,000 + \$15,000$) from the total annual gains of \$31,500 ($\$18,000 + \$13,500$). The present value of net benefits is then calculated and compared to the investment cost of \$150,000.

Figure 1: CBA of a Public Project: A Public Beach

BUSINESS COMPETITIVENESS: KEYNESIANISM VERSUS NEOLIBERALISM

Keynesianism was established during the interwar period, when most European countries were dealing with very high unemployment levels as a result of the massive destruction occurred during World War I, which was followed by many other disasters, from the global pneumonia epidemic to the hyperinflation phenomenon occurred in Germany, often held responsible for allowing the Nazis to takeover the *Reichstag*.

The Keynesianism theory was first published in 1936, with the book "General Theory of Employment, Interest and Money" (Keynes, 1936). As Dernburg (1985: 9) notes: "Keynes showed that market forces could not be relied on to ensure full employment as a norm and that the problem from which the economy suffered was inadequate aggregate spending. He also had doubts about the ability of monetary policy to restore sufficient spending, and he suggested that help had to come from another source. Thus Keynes laid the foundation for the view that government's budget could be used to offset excesses and differences of private spending in a way that places the budget in the role of balance wheel".

Contrary to the classical economists, Keynesians are less optimistic about free-market economies and their ability to quickly and effectively respond to shocks. One of the main ideas in Keynesianism is that wages and prices are

"sticky" and do not adjust quickly to mobile market levels (vid. e.g. Erceg *et al.*, 2000). Wages and prices inflexibility implies that the economy may be far from its general equilibrium for a significant period of time. Thus, a deep recession of a free market is not an optimal response to external shocks, but rather is an unbalanced situation in which high unemployment reflects the excess labour supply over demand for labour. Keynesians believes that government should act to compensate these low production and high unemployment periods, i.e., to minimize the impacts of an economic cycle downturn.

In a typical dictionary of economics (vid. e.g. Black, 2003), Keynesianism is described as a moderate compromise between national regulation and social ideology, which also matched with the need for recovery and reconstruction of Western economies.

Burda and Wyplosz (1997: 413), offer this Keynesian view: "a radically different approach to thinking about the microeconomic assumes that the prices level is no longer perfectly flexible, but instead is constant." Keynesians explains inflexibility with two main ideas:

1. That most of active companies set their prices, and do not worry or think that prices are given by the market.
2. That when firms change prices, they are mostly worried about costs, which has been called as the menu cost.

Furthermore, according to Burda and Wyplosz (1997: 413): "Keynesians worry about unemployment and slow growth. Because they believe that market outcomes can be improved upon, they contrive ways of correcting them by activist policies."

As discussed earlier, if Keynesianism was the standard for around half a century, that suffered a major shift in the 1970s, when Neoliberals offered the solution for the new stagflationary condition. Neoliberalism, also called Neoclassicism, became mainstream from the 1970s until nowadays, a role reinforced in the meantime with the fall of the Berlin Wall, and the increasing development of the globalization process. Unsurprisingly, the policies preconized by Neoliberals are supported by the World Bank and the International Monetary Fund.

The term "neo-liberalism" was probably first used in the post-World War I in Germany by a small group of economists. Neo-liberalism appeared with the purpose to revive Liberalism. As Todaro and Smith (2003: 128) pinpoint, "the central argument of the neoclassical counterrevolution is that underdevelopment results from poor resource allocation due to incorrect pricing policies and too much state intervention by overly active developing-nation governments".

Neoliberals' theory supports the arguments of reducing governmental regulation and weight in the economy, by privatizing state-owned corporations (e.g.), which,

therefore, would contribute to the development of independent markets. Neoliberal theory argues that if a set of liberal policies is adopted, including the allowance of free market's progress, privatizing public corporations, encouraging growing of free trade and export, welcoming investors from developed countries in the form of foreign direct investment, then economic growth and effectiveness will be improved. This theory provides freedom for developing private sectors and encourages performing from individual investors and entrepreneurs.

Despite the outstanding importance of both Keynesianism and Neoliberals theories, it is important to stress that they have been developing, being now substantially different in several ways from the thinking that was popular in the period between 1945 and the 1980s. From the post-World War II era that the prevailing theory of employment estimation was Keynesianism, which argued that the level of economic activity is a function of the level of aggregate demand. Moreover, Keynesians asserted that capitalism is subject to repetitive generational downturns in the economic cycle, leading to a failing in the entire demand generation process, and therefore resulting in unemployment. Sometimes, this weakness in demand may be more significant and provoke an economic crisis. In this case, monetary and fiscal policies can be used to normalize the demand generation process.

Keynesians have always accepted an ordinary theory of employment determination; they have always been divided according to the theory of income distribution. This division may also help to justify the triumph of Neoliberalism, at least theoretically.

In the 1940-1950's a few American economists, leaded by Paul Samuelson (1954, 1955, 1958), put a lot of efforts to combine Neoliberalism and Keynesian schools, creating a more "positive" neoclassical economic theory.

Regardless the views, but taking into consideration the current dominance of Neoliberalism, one can argue that the most important thing is to have available a pragmatic economic system that can successfully overcome the economic life-cycle failures, particularly in respect to unemployment and inflation, combining and being successful to reconcile the two main economic principles: an effective public control the market, while ensuring it can operate as free as possible.

From our point of view, Keynesianism may offer better policies when a given country faces an economic crisis, because in that situation a government is able to analyze more comprehensively specific situations in different industrial sectors, set a proper level taxation, and helping to stimulate the economy with public investment and expenditure. This seems obviously arguable, but provided that there is a public budgetary surplus.

On the other hand, Neoclassicism may offer superior policies as it provides bigger flexibility and economical freedom. As everything, both these theories stand on

their own merits, and therefore have their advantages and disadvantages.

As an aftermath of the current economic and financial crisis, many are considering that nowadays the society needs a new kind of economic theory, perhaps such as an "improved" positive neoclassical economic theory. A refreshment in the theory that could not only help to face better the crisis, but also that could contribute to a fast development of the global markets. However, it has to be recognized that this purpose is not an easy one, as the current economic theories have already gone through a long process of development and refurbishment.

CONCLUSIONS

In this paper work we have discussed the role and importance of different economic theories from Mercantilism to Communism, but with a particular focus on Neoclassicism and Keynesianism.

Neoliberalism was compared with the Keynesian theory, allowing understanding the effects of their policies in the economy. It seems obvious that the best way to deal with an economic crisis is to use the most suitable economic theory. Taking into consideration the current economic-financial crisis, and the current crisis of sovereign debts, from our point of view the best offer comes from the neoclassical economic theory, probably in its "positive" form, i.e. integrating some Keynesian theory. Indeed, this comprehensive and perhaps more pragmatic theory may include the best policies of both Keynesian and Neoclassical theories, and making it more diverse and productive.

The economic and social reality is complex. As complex as the human nature, where white and black stand for extreme, abnormal, conditions. In normal conditions, grey shades are the pattern. We understood that there is no particular economic theory which works perfectly in any economy of our world. To develop a suitable economic theory, existing theories should be probably mixed and assembled.

Finally, the importance of cost-benefit analysis has been discussed, being its main steps described. Its importance for decision making has also been discussed. Due to size limitations, it was not possible to examine further the CBA in this paper, in the scope of the economic theories, particularly to Neoclassic theory. CBA origins come from the need of higher efficiency and effectiveness in public investment, being therefore critical for governments. But CBA became also a useful tool for the private sector, being therefore very important in the scope of the Neoclassical theory.

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THE EVALUATION OF BIOMASS POWER PROJECTS

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KEYWORDS

Biomass, Energy Costs, Feed-in Tariff

ABSTRACT

Biomass is a renewable energy source attracting increasing attention. At the EU level in the last years a set of activities and programs were implemented in order to support and promote the use of this source of energy. This study addresses the issue of biomass costs for electricity production and the importance of incentives schemes such as feed-in tariff for the economic development of the sector. An economic evaluation of the electricity production from biomass is presented, based on a survey of both financial and social costs applied to the Portuguese case. Economic assessment was carried out by taking into account three types of biomass: energy crops (*miscanthus*), forestry residues and municipal solid waste. Four set of costs were considered and included: cost of capital, cost of maintenance and operation, fuel costs and external costs.

INTRODUCTION

One of the most relevant and worrying issues related to the energy sector concerns to the continuous increase of the energy dependence of most countries in recent years. The growth of the pollution levels along with the shortage of the fossil fuel reserves creates concerns that represent strong motivations for the development of new power plants assumed to be environmentally friend. The high efficiency of the biomass power plants along with the use of a fuel associated with renewed life cycles and their possible positive social impacts in particular at regional level, turn biomass an interesting alternative for the electricity generation (Carneiro and Ferreira, 2010). The Biomass is seen as an energy source that can play a key role for the fulfillment of the goals of the renewable power plants, as it can contribute for the supply of energy in three sectors, electricity, heating/cooling as well as in the sector of biofuels (Council of the European Union, 2007). The increase use of biomass represents also an opportunity to reach a reduction of the greenhouse gases emissions, contributing to the concretization of the international environmental commitments, promoting also the forest management along with the regional development.

This study addresses the issue of biomass costs for electricity production and the importance of incentives schemes like feed-in tariff for the economic development of the sector.

Next section briefly presents a theoretical introduction addressing the topic of electricity generation from biomass and the types of biomass available. In Section 3 an economic evaluation of the electricity production from biomass is presented, based on a survey of both financial and social costs applied to the Portuguese case. The main conclusions are summarized at the end.

BIOMASS AS ENERGY SOURCE

The biomass is a heterogeneous energy because it can be provided by several sources like plants, animals and micro-organisms (Bhattacharva et al, 2003), and is used to meet a variety of energy needs, including generating electricity, heating homes, fuelling vehicles and providing process heat for industrial facilities.

To Berndes et al., (2003) biomass has the potential to become a major source of global primary energy over the next century, once it can contribute to many important elements of national or regional development: economic growth through business expansion and employment; import substitution, security of energy supply; and energy source diversification (Domac et al., 2005).

From the environmental point of view in general it is considered that biomass energy can play an important role in reducing greenhouse gas emissions, since when produced and utilized in a sustainable way, the use of biomass for energy offsets fossil fuel greenhouse gas emissions (Hoogwijk, 2009). This characteristic makes the biomass an energy source that can play a key role for the fulfillment of the goals of the renewable power plants.

Energy production – types of biomass

The biomass that can be used for energy production can be of two types according to their origin: (i) biomass produced by agricultural or forestry activity, in form of waste and subproducts, or (ii) biomass for energy purposes (dedicated production). Currently, forest residues, agricultural and urban, are the main raw materials for producing electricity and heat from

biomass. In addition, a small share of dedicated crops is used as raw materials for production of liquid biofuels (IEA Bioenergy, 2010).

The availability of organic waste for energy use depends heavily on variables such as economic development, consumption pattern and the fraction of biomass material in total waste production. In what concerns agricultural waste, the potential depends on food production. For energy applications, which require the continued availability of biomass, it is necessary to take into account that agricultural residues are characterized by their seasonal availability and, therefore, needing storage for long periods. This storage may easily lead to change on the residues characteristics due the fermentation process. Biomass sources that are already concentrated in one place, often as a sub product of another process, tend to be cheaper since they require less intensive collecting and treatment procedures and have no production costs. Many agricultural and forest residues are not competitive with fossil fuels due to the dispersion over large areas in small volumes (IEA Bioenergy, 2005). In relation to forest residues, these are the most valued, since the areas of forests cover at present about 30% of the surface of the globe. However the energetic potential (sustainable) of forests in the world is uncertain.

Therefore several assessments of the potential supply of biomass show that the greatest opportunities for biomass production in Europe and in another places is in the dedicated energy crops (Ericsson and Nilsson, 2006). According to Berndes and Hansson (2007) the adoption of land for the production of energy crops can be considered as an option for the various challenges in the agricultural sector arising from EU enlargement, such as the abandonment of land, the rising of unemployment and an exodus from rural areas. The contribution of energy crops will depend on many factors, including culture type, management, climate and soil.

ECONOMIC EVALUATION

A viable substitute of fossil fuel must have not only a better environmental performance, but must also be economically competitive in order to attract investors, and at the same time must give an important contribution to change the general balance of primary energy use (Domac et al., 2005). An important limitation of the use of the biomass as an energy resource can be the economic costs.

An economic evaluation of the electricity production from biomass is presented, based on a survey of both financial and social costs applied to the Portuguese case. Economic assessment was carried out by taking into account three types of biomass: energy crops (*miscanthus*), forestry residues and municipal solid waste. Four set of costs were considered and included: cost of capital, cost of maintenance and operation, fuel costs and external costs.

For the determination of Net Present Value (NPV) the present value of the estimated cash-flows is computed, based on a previously defined rate of return. As the economic analysis intends to go further than the financial analysis, the externalities were monetized and included in the economic study. Thus, besides the NPV (financial) the NPV (full cost) was also determined.

As a final note it should be underlined that being biomass a renewable resource is protected by law and benefits feed in tariff. Feed-in tariffs (FITs) are guaranteed minimum prices established by the government and paid by utilities to generators of electricity from renewable energy sources (RES) for a guaranteed minimum number of years and is by far the dominant model in EU (Ferreira and Vieira, 2010).

Table 1 and 2 presents the results of the proposed simulation. The conversion technology considered was the gasification and the values of external costs were taken from the ExternE study. These costs were updated to 2010 according to the Portuguese price growth.

Note that Social costs is the sum of Financial and External costs.

Table 1: Results of hypothetical scenario for miscanthus case

Costs	Present Value	Unit	Total Costs	Value	Unit
Investment	21.960.000,00	€	Financial	51.621.119,80	€
O&M	7.511.210,90	€	Social	58.733.701,67	€
Fuel	22.149.909,00	€	NPV (financial)	1.046.441,60	€
External	7.112.581,89	€	NPV (full cost)	- 6.066.140,27	€
Present value of sales	52.667.561,40	€			

Table 2: Results for forest biomass and municipal solid waste for the case of Portugal

Forest biomass			Municipal solid waste		
Costs	Value	Unit	Total Costs	Value	Unit
Financial	51.401.858,06	€	Financial	49.905.061,18	€
Social	58.449.780,11	€	Social	59.426.221,93	€
NPV (financial)	786.907,33	€	NPV (financial)	- 14.983.156,67	€
NPV (full cost)	- 6.261.014,72	€	NPV (full cost)	- 24.504.317,42	€

The results show that the investment costs along with the fuel cost represent the highest share of the total financial cost for all cases. Higher values for the financial and social costs are obtained for energy crops and forest biomass, with the municipal solid waste (MSW) presenting the lowest value. For this different result contributes mainly the value obtained for fuel costs

reported to moment zero: 45.0 €/MWh for the forest biomass and for dedicated energy crops and 30.0 €/MWh, for MSW. The costs of O&M are also approximately the same for both forest biomass and for dedicated energy crops with the municipal solid waste, presenting once more lower costs.

However, the negative values obtained for the financial and Social NPV in the case of municipal solid waste are mainly due to the reduced feed-in tariff. In fact, the present feed-in tariff is 54 €/MWh for municipal solid waste, a clearly lower value than the price for the forest biomass and energy crops (107 €/MWh). The differences in the obtained NPV values are largely explained by the different feed-in tariffs. Therefore, the increase on the applied tariffs contributes deeply to increase the interest over these projects and is a key factor for its financial viability. The external costs, despite representing a smaller value than any other financial cost components, lead to a negative value of NPV (full cost) for energy crops and for the forest biomass, also reducing significantly the values of NPV for municipal solid waste. In a first approach cost values related to gasification technology were used, in order to allow a comparison between the three types of biomass. However other simulations were made for the particular case of direct combustion, so that it would be possible to investigate how the chosen technology affects the viability of these projects. In the analysis for the forest biomass, gasification technology presents the best financial results, with a positive NPV (financial). The reason for this is the assumed conversion efficiency for the gasification higher than the combustion technology efficiency, reducing the cost of fuel. As for the municipal solid waste, the second alternative (combustion technology) presents as more favorable result, with total financial costs slightly below the gasification technology. In the particular case of energy crops, gasification technology presents total financial costs well below the obtained with combustion technology (steam cycle). This is once more due to a significantly higher value of fuel costs for the combustion technology (126 €/MWh) against 45 €/MWh for the gasification technology. The results indicate a negative financial and social NPV for the steam cycle (combustion technology), while for gasification, when the external costs were not included, the NPV was positive.

Sensitivity analysis

A sensitivity analysis is presented focusing on the most relevant variables for the evaluation and subject to a higher uncertainty. The sensitivity analysis allows to draw various scenarios, and to verify to what extent the viability of the project changes when the assumed values change. The results demonstrated that the discount rate, efficiency and feed-in tariff are the most important

parameters influencing the viability of biomass plant. Due to high capital costs of biomass power plants, the financial results of the project will be highly favored by a reduction of the considered discount rate. As for the efficiency, the rate of the impact depends of the type of biomass used and of the selected technology. The efficiency of the process influences the fuel costs, and as demonstrated the fuel cost is one of the most important parameters influencing the economic viability of biomass plant. For the sensitivity analysis of the feed-in tariff, obviously as the value of the feed-in tariff increases, the project becomes more attractive.

Feed-in tariff

FIT prices are usually established in law. FIT prices can be as low as four and as high as thirteen times regular prices. Those values are determined by politics, not by market economics (Richard and Barclay, 2009).

In the most countries feed-in tariffs have been suffering adjustments over the years, in order to create conditions to attract investors to a sector that is expected to contribute to emissions reduction of the external energy dependency. The feed-in tariffs attract much capacity, since a fixed tariff is guaranteed, but only if the feed-in tariff is set at level sufficient to meet investor needs. The level and importance of feed-in tariffs may vary significantly among countries, depending on national characteristics such as the potential and costs of renewable resources or the political preferences regarding policy instruments to promote renewable electricity (Richard and Barclay, 2009).

The results of the Commission of the European Communities study (2005) demonstrate that for biomass forestry, the feed-in tariffs defined for half of the EU Member States hardly allow to cover generation costs. Denmark, Finland and Netherlands present the smaller gap between feed-in tariffs and generation costs. As for France, Greece, Ireland, Luxembourg, Portugal and Spain, the feed-in tariff support does not seem to be enough to bring about a real take-off in the biomass sector.

It has been shown that feed-in tariff is as expected a key factor for the project viability. The required feed-in tariff to make the project financially interesting from the point of view of a private investor, for the Portuguese case was estimated. According to the simulation conducted and to the assumed conditions, the feed-in tariff that would be required to make the project financially interesting from the standpoint of a private investor would be equal to or greater than 120 €/MWh for dedicated energy crops.

CONCLUSION

This study addresses the issue of biomass costs for electricity production and the importance of incentives

schemes like feed-in tariff for the economic development of the sector.

Bioenergy may be able to offer socio benefits in Portugal compared to other energy sources, like the possibility to create direct and indirect jobs but economically, while the value of feed in tariff continues the same, the viability of this type of energy is uncertain. It can be concluded that a higher value of feed in tariff for biomass could lead to greater interest in these kinds of projects. Lower tariffs turn the project not interesting under the financial point of view of a private investor.. According to the literature reviewed, in nearly half of European countries, the support for biomass forestry is insufficient to develop this high-potential sector further. Future works should approach more in detail the question of choosing the appropriate energy cultures, a parameter that influences significantly the financial viability of the project. Although the external costs continue to represent a considerable part of the social total cost, it is important to notice that is difficult to determine the externalities of biomass with precision, due to the heterogeneity of this spring of energy. Once again, the future works should contemplate the determination of these external costs for the Portuguese case, having in consideration the economic characteristics of the regions with bigger agricultural potential for energy crops, in order to select the relevant variables for analysis and then proceed to its monetary values translation.

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A COST-BENEFIT ANALYSIS OF AN INTELLIGENCE AND DEMAND-RESPONSIVE PUBLIC TRANSPORT SYSTEM FOR ELDERLY AND DISABLED

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KEYWORDS

Transport demand for people with reduced mobility, Externality, Cost-Benefit analysis

ABSTRACT

The current road public transport systems in Portugal are not suitable for most of its inhabitants, in particular those who suffer of reduced mobility. This inadequacy is mainly due to the lack of flexibility of the transport services provided and the poor level of physical accessibility (pathways and in-vehicle facilities). This study aims to estimate the effects of the implementation of public transportation systems designed to meet the specific market of public transport demand of people with reduced mobility (e.g. elderly and disabled). The main factors affecting the system must be translated into a number of criteria and indicators to be included in the evaluation of potential transportation projects in this area. The study is based on a literature review and focuses on the analysis of externalities and decision making about public transport. From this review it is intended to develop an analysis of the externalities of the projects. It will be also discussed the cost-benefit analysis for the project aimed at ensuring the sustainability of a transport demand for people with reduced mobility (TDPRM).

INTRODUCTION

The current collective passenger transport by road in Portugal is not adequately equipped with support equipment for transporting persons with reduced mobility. Furthermore, the typology of services provided is not suitable for this purpose, because these services are based on fixed-schedule and fixed-route routines that have been designed to couple general public demand.

On the other hand, public transport demand for people with reduced mobility is far from being negligible, and tends to increase as population is aging and individuals

are increasingly aware of their social rights. Therefore, it urges to develop adequate transportation systems to satisfy their needs. These systems are not necessarily more costly than private car usage. In a case study carried out by Jakob et al (2006), it was found that the direct cost of using private transport is higher than the public transportation cost, even when added the indirect cost. These points to the clear benefit from using public transport to the detriment of private transport.

The public passenger transport is undoubtedly a driver for promoting the social inclusion, but it is also a right. A society that does not respect these two principles excludes its own citizens as well as their contribution to society itself.

Many citizens with reduced mobility are seniors and it is predictable that their number continues to rise. The increase in longevity and medical advances allow the elderly a better quality of life. Persons with disabilities are another group that has reduced mobility. Also here, the inclusion has not evolved only by the desire they have to contribute to society, but mainly by the change in mindset of society towards them.

The main objective of this study is to analyze the externalities of urban passenger transport for people with reduced mobility. The study will take into account the externalities that are typical of traditional public transport, but also the externalities that are inherent to the development of a transportation system specifically designed for people with reduced mobility. The benefits of the transport of persons with reduced mobility in a specific system are not due just for the simple fact mobility for everyone is ensured, but represent also a range of benefits for the society as a whole.

The paper is structured as follows. Section 2 discusses the concept of externality in the context of a general transit system. Section 3 focuses on cost-benefit analysis in making strategic decisions applied to conventional public transport. Then, Section 4 presents the characteristics of a TDPRM project for urban areas. Section 5 discusses the criteria that must be considered

in the analysis of externalities related to that project. Section 6 presents the costs and benefits to be included in future analysis of the project. Finally, Section 7 reports the key findings of this research that are relevant to decision-making.

EXTERNALITIES IN TRANSPORT SYSTEMS

Definition and the case for internalisation

The development of any activity may have economic impact on others. When this impact unintentionally generate costs or benefits, then such an impact is designated as externality. The damage caused is mostly not integrated in the price system (ExternE, 2010). Also, this damage is not reflected in the products sold or the price system due to be resources where it is not possible for achieving maximum efficiency (Bin & Xinjie, 2009). Whenever the impacts bring some benefits, they are usually called by positive externalities; on contrast, negative externalities are associated with costs. In this paper, the internalisation of externalities is discussed for the purpose exposed by ExternE (2010): "This internalisation of external costs is intended as a strategy to rebalance the social and environmental dimension with the purely economic one, accordingly leading to greater environmental sustainability."

Externalities

Transport systems have a significant contribution in the development of any society. They are also the cause of a significant set of positive and negative externalities; few other human systems probably have an equal or higher impact on society in terms of externalities. Transportation externalities have been recognized, but are hardly accounted for, because this does not have a direct impact on the transport itself. Negative externalities are the most cited, not only by their direct impacts on people's lives, but also by the easiness of recognizing them. The most common negative externalities of transport are traffic congestion, accidents, greenhouse gas emissions or environmental pollution and noise.

(Zhu et al, 2008) consider that congestion has become the limiter factor in the activity and the development the economy of cities, also affecting the development of sustainable cities. The stress that people acquire due to congestion can directly affect the income in their work, as well as the relationship between co-workers, family and even customers themselves.

Road transport represents a significant share of emissions of greenhouse gases, particularly CO₂. The result is a potential climate change problem that has led to a political consensus of principal world leaders, in order to implement some actions that are required to reduce these emissions. The costs of prevention could be lower than the costs that result from climate change. (Bin and Xinjie, 2009) believe that environmental damage and environmental pollution is one of the most common and serious problems associated with transport-related externalities.

The release of gases from vehicles not only affects the environment in what concerns the greenhouse gas effect, but also generates a significant increase in air pollution, with negative impacts on the health of human beings (Bin and Xinjie, 2009).

Urban areas are the places where the effects of pollution are mostly felt, mainly due to the concentration of a high number of vehicles in a limited space. Air quality, noise pollution, vehicular traffic and public transportation availability and accessibility are becoming important factors to consider when ones choose where to live. Therefore, these factors have a direct impact on the local economy.

The policy measures for cost reduction tails on the greenhouse gas effect and even on the control of air pollution has a greater effect when applied on transport compared with other sectors (Van Dender, 2009). (Van Dender, 2009) supports that energy policies should delineate more ambitious goals on a large scale, and promote the development and use of alternative technologies, mainly through more efficient use of vehicles and/or use of alternative fuels.

Ambitious objectives probably can only be met at a reasonable cost. However, because uncertainties are high (e.g. in the true effects that negative externalities will have on the environment; in economical evolution), it has been observed many efforts to develop alternative technologies and to bring them to the market. High fuel prices through higher prices before tax are a major incentive in this context (Van Dender, 2009).

Public transport companies may need to have access to lower prices of fuel, so that fickleness in fuel price will not reflect in the price of transportation paid by users. Such type of measures can persuade people to switch from private transport to public transport, thus inducing a better urban environment and quality of life.

A large fraction of noise that exists in urban areas is due to movement of vehicles and the intrinsic characteristics of those. (Bin and Xinjie, 2009) consider that the vehicle speed, vehicle type, the type of tires, and the

condition of the vehicles are the main factors that are responsible for the emission of noise. Beyond these factors, the authors also report stress factors, such as age of the vehicle, the track gradient, surface type, and driving behaviour, which also contribute to noise pollution.

Accidents are also an important externality in transportation. The greater the number of vehicle travelling, the greater is the probability of occurring accidents. There is always a cost regardless of the accident according the damage they can cause. Accidents can result only in traffic congestion, or they can be extremely serious, as in the case of death or disability of the occupants, resulting therefore, in this case, in a high cost to society.

COST-BENEFIT ANALYSIS OF PUBLIC TRANSPORT

The cost-benefit analysis should be an important factor when making strategic decisions. When it comes to transportation, the decision should not be the simple analysis of economic-financial viability, because the final decision will directly affect people's mobility, road safety, health - due to pollution, the environment and economic development region.

The cost-benefit analysis is a method widely accepted and used by decision makers, advising on specific criteria to be taken into account in decision making and ensuring that the benefits to society outweigh the overall costs. Therefore, any investment project, mainly in the public sector, must be accompanied by a cost-benefit analysis in order to enable the evaluation of the project (Nickel et al., 2009). Beyond the economic variable easily accounted for, it is important to account for non-economic variables, such as noise, accidents and air pollution, among others. This has been the biggest problem for the application of the method (Tudela et al., 2006) due to the complexity and subjectivity of transforming these variables in monetary value, because it has not an established market and each person can assign a different value. The estimated value for these variables should address the different factors of a more global point of view. Each factor may be in more than one variable, but should be counted only once, to enable a proper analysis.

The cost-benefit analysis is used by decision makers as a way to justify their decisions or even to make that decision. However, the method of cost-benefit analysis is not the only method to be used for decision making or evaluation of a project. Through the application of different methods on the problem, different results can

arise. So, the key issue is that of identifying the problem and its main features. This can be a key factor for the correct choice of method. Here too, there is some subjectivity in the choice of method and that is the decision makers' responsibility.

(Nickel et al., 2009) use the method of cost-benefit analysis and the method of Multi-Attribute Tradespace Exploration (MATE), developed by MIT (Massachusetts Institute of Technology), to assess projects. The paper presents the case study "airportexpress" to the city of Chicago and the case of high-speed railway line from Lisbon. The underlying idea of the MATE method consists on perceiving the values of stakeholders and thus creating decision metrics, by assigning a high importance to the key factor. This method aims at improving the expectations, given to interested parties. The methods used are different, but they should be used complementary for a better decision making.

The cost-effectiveness analysis allows evaluating the efficiencies of different projects, comparing them, and making the decision based on the best efficiency. The cost-effectiveness analysis allows to assess the effectiveness of a given technology, program or policy. According to its effectiveness, a measure can be defined in terms of its degree by which the objective and/or goals are achieved (Browne and Ryan, 2010). This method assumes that the costs and direct benefits can be estimated (quantified) in monetary values. The objective is to select the project with greater profit (the difference between benefits and costs).

The *Multi-criteria decision analysis* is also addressed for project evaluation (Browne & Ryan, 2010) as a way to make the decision on choosing the best project. The method transforms the option on a scale or matrix to assess the impacts comprehensively. The options involve determining the alternatives, comparison criteria, assigning weights to each criterion and definition of ranking of satisfaction.

By turn, Tudela et al. (2006) suggest a multi-criteria technique called Analytic Hierarchy Process, which consists of assigning weights that reflect the importance in the hierarchy. A hierarchy consists of separating the different attributes and alternatives, and thus assign criteria according to the hierarchy. In the end, the selection of project results from the best compromise.

Whichever method is chosen, the goal is to select the best perceived overall decision, taking into account every aspect of the project, but also the impact this will cause.

In general, a transportation cost-benefit analysis should consider the costs and benefits, and within these, the

focus must be on economic, environmental and social issues. The gain in travel time, reduced fuel expenditure and reduced waiting time at stops, among many others, are examples of economic benefits. Improving access to transport, mobility, social inclusion, sustainable development, are examples of social benefits.

In terms of economic costs, the list of factors includes the initial investment, maintenance costs, operational management and structure, congestion, etc. In terms of social costs, it can be highlighted the diseases caused by exhaust gases, noise and accidents. As environmental costs, the most important are the greenhouse effect and the release of other pollutant, which cause degradation or even destruction of fauna and flora.

TDPRM IN URBAN ENVIRONMENTS

The transport request arises in order to remedy the inadequacy of conventional public transit passenger who does not respond efficiently to lack of demand in areas of low population. The transport request is a service directed for customers, i.e., an only vehicle shifts to a stop, if there is one or more client to enter, exit or both, in that place. Thus, the service's main features are the absence of timetables and routes pre-defined, using small and medium size vehicles, according to demand.

In urban areas, the demand for public passenger transport is usually high, but there is a market in the urban areas in Portugal that public transport is unable to cover. The conventional public transport is unable to do transport or often tries to avoid it, in the case of people with reduced mobility. In this context, it is justified to develop an alternative system, flexible in terms of schedules, stops and routes, and adequately equipped for people with reduced mobility, in order to be effective and efficient, but also financially viable.

Characterization of the project

As referred before, the number of people with reduced mobility has been increasing over the years and prospects are that this will continue to happen. There are some factors that lead to it, such as greater longevity of people, regular physical activity that allows you to have a healthy life, better health care ensures a healthy life and allows disease prevention. But personal mobility naturally decreases with aging, as well as the ability to overcome obstacles, and these factors greatly limit access to public transport.

A measure used by passengers of public transport to classify them in relation to its efficiency is, with out any

doubt, that transport has the ability to meet its own timetables. In what concerns the schedules, a certain pressure for the different elements of the system to make it happen exists. This has direct implications on the people who take a little longer to get on or off transport, a clear example of people with reduced mobility. On the other hand, most of the vehicles do not have adequate structures to facilitate the access of those people. Therefore, for them, there is a general lack of accessibility to transport means and, as a consequence, lack of accessibility to many services, which leads, at some extent, to a functional social exclusion.

Given this situation, a person with reduced mobility does not have an efficient public transport service for its transportation. The transport request applied to the urban environment can be addressed and evaluated as a possible solution because of the flexibility in terms of route. The time taken for boarding or landing may be less compared to a conventional transport, but the client itself can also set how long he/she needs to boarding or landing. Also the characteristics of the vehicles are suitable for this type of passenger. Bu using a heterogeneous fleet of vehicles (of small and medium dimensions), drop-on and off points do not need to be bus stops, but only a single set point between the customer and the central, in many cases can be at the customer's door. In this way, the system also avoids the outline of physical barriers that turns difficult or even impossible the mobility of users.

TDPRM CRITERIA TO CONSIDER

A TDPRM project may not be financially viable by itself in light of the private traditional perspective. There are however some parameters that must be thought out and considered the act of decision making , especially by public entities involved in the project , and who can demonstrate the social desirability of the project . The externalities of the project can justify its implementation in a wider perspective, due to the positive impact that this may have on society.

Mobility is a right recognized by all, but it is also true that this is not always the case. In reality, it is difficult to find a public transport system for people with reduced mobility at an affordable price. Most current public transport is unable to transport these people. Some people with physical disabilities also have great difficulty in walking with an additional problem, in many cases, that is equipment the need for its locomotion. The absence of public transport able to guarantee the mobility of these people causes them to

turn to a more expensive solution to ensure minimal individual autonomy.

Also accessibility to some stops or walk on sidewalks sometimes is extremely difficult. A door to door service is more adjusted to allow the client to avoid a set of barriers that constraints their movement. In addition, access to some points is difficult, if not impossible, due to lack of suitable ways, the existence of physical barriers, lack of civic responsibility on the part of others people, the physical and emotional difficulties on the part of individuals with limited movement.

In general, older people do not suffer from reduced mobility only, but also they tend to suffer from other health difficulties such as sight or hearing. Therefore, public transport tends to be even more unsuitable to accomplish their real needs. In many cases, those people opt to use their own private vehicle. Here arises a problem related to road safety due to reduced natural senses by the elderly, which leads to increased likelihood of suffering or even cause an accident. Traditional public transport simply tries to accomplish their schedules and routes, and any incident that occurs along the route has a direct influence on the person who uses this transport. For example, a small delay can have a great consequence, principally when there are transfers. A loss of transshipment may cause delays of hours at the final destination and therefore the existence of costs (working hours, loss of consulting or classes, etc.). In this sense, people with mobility problems are "motivated" to not to use these mean of transport, by which the existence of an alternative transport system, there will be room for improvement in efficiency of public transport passengers.

In essence, the transport request also requires an efficient planning. Since the system is centered on flexibility, requires a daily planning. The efficiency will be reflected in a reduction of the negative effects that are associated with transportation and its costs. The cost reduction enables greater financial viability, since the customer must pay a value very close to that it is paid for a conventional public transport service.

The service provided will increase the supply of public transport, with the advantage of being more flexible, and remains a service supplied at an affordable price for all, thus contributing to greater social inclusion.

Traffic is a major problem in urban areas, but this can be reduced if people opt for collective public transport to the detriment of private car. An increased use of public transport is reflected in urban traffic: for the greater utilization of public collective transport, the lower the utilization of private transport, causing a reduction in traffic and a consequent reduction in

congestion. With this reduction, the negative effects associated with congestion are also reduced.

The specialized transportation for people with reduced mobility will also benefit their direct family members since. In certain situations, family members will no longer need to accompany or to transport the person. Thus, the family members will not have to miss their work, and companies can be better off in an indirect way, since they do not need to make changes in the management of human resources.

With some frequency, some people fail to do certain medical treatment due to not having suitable transport or to being too expensive for their economic possibilities, or to needing assistance equipment for moving. The absence of treatment may have serious consequences for patients, but with the worsening of the disease higher costs both for patients and for the health unit will be incurred. With the worsening of the disease, those responsible are "obliged" to ensure that patients are under treatment, but it is necessary to determine their hospitalization, which increases the costs of the NHS. In addition, it cannot be neglected the pain that each patient feels: this cannot be quantified in terms of cost, but has a direct impact on treatment costs and quality of life of patients and their relatives.

Currently, the transport market that is directed to senior people is still very small, but it is expected that it will increase with the longevity of the people. The demand can grow significantly and as so this market is also expected to grow. Similarly the demand for public transport appropriate to the condition of the senior will also increase, but they will look for system that provides flexibility in terms of schedules and route.

The solitude of seniors is an increasingly requirement of our society. This reality added to their difficulty or lack of mobility, makes these questions (solitude and social exclusion) even more accentuate.

Now days, in this area, worldwide targets are ambitious but fundamental. They aim to increase road safety, reducing the percentage of road fatalities, reducing levels of congestion and air pollution resulting from road traffic, public transport should be like a bet on the direction to achieve these same goals. Alternative transport systems, targeting a more specific market, including elderly and disable, have been encouraged by different governments.

Public transport collectively should not be looked only by the financial perspective, but mainly from a social point of view. The importance of public transportation for the welfare of people and the environment are factors that are increasing in people's minds. Therefore this stresses the importance of alternative systems,

towards to increase the efficiency of public transport as a whole.

In short, the demand TDPRM ensure mobility, especially for people who have limited mobility and proved at least an alternative in terms of transport and with suitable prices. Structure of vehicles should be more adequate to serve the different classes of people. Road barriers must be eliminated or reduced in order to banner the physical and psychological mobility of people.

With the reduction of capacity in normal older people, raises the issue of road safety, but also which is the contribution to increasing congestion.

The implementation of an alternative system to transport people with reduced mobility, allows public transport to be more effective in their journeys and avoid problems with delays.

The efficient planning allows optimal distance and occupancy rates, beyond meeting the real needs of customers. The competence of the staff allows people to not require more accompanying (e.g relatives).

ANALYSIS OF THE PROJECT TDPRM IN URBAN AREA

The TDPRM may not be fully self-sustaining from economical-Financial point of view, if presenting an acceptable price for everyone especially for the most socially disadvantaged groups. However the impact that this system will have for society as a whole will be able to justify its implementation. The possibility of using the cost-benefit analysis applied to a system of collective public transport passenger for people with reduced mobility will be now explored. , The main factors to consider in evaluating the project will be described, aimed at being able to justify the possible support by the public agency.

For the cost-benefit analysis of this project some factors that coincide with the conventional public transit passenger must be considered. Thus, some externalities are common to both systems but there is however a number of other that are important to consider, in particular when the project is analysed in social terms. The analysis may consider costs and benefits directly and indirectly. The direct costs or benefits result from the implementation of the project. While the indirect effect (cost or benefit) is related to the third ones, for example the reduction of disease caused by pollutants released by vehicles, the benefit is directly related to the greater mobility of the driver, but the pollutants released

by the vehicles have impact on others causing them breathing problems, for example.

In order to understand the cost-benefit analysis, we enumerate a group of factors that should be considered in the analysis. These are grouped by the direct benefits, direct costs, and indirect benefits and indirect costs.

Direct benefits:

1. Reduction of obstacles. The system should be a shuttle service, door to door, that is, the picking or delivery of persons occurs on site most appropriate for their objectives. The service allows people to walk as little as possible while avoiding obstacles and barriers that are common on the road and a lot of time prohibitive to their mobility.
2. Suitability of vehicle physical conditions of the people. The characteristic of the vehicle allows people to drop-in more easily because it has a mechanism for facilitating access, for example board lift or ramp access to the interior for wheelchairs.
3. Providence of a specialized service. People who practice the services should have sufficient training to understand and deal with the people concerned.
4. Creation of workstation, both direct (employee of the company) and indirect (to provide training).
5. Availability in terms of both schedules both for to perform as for to request, so the service goes against the real needs of customers.
6. Improved mobility of persons with reduced mobility. These people tend to be safeguarded at home to avoid a set of obstacles, thus excluding themselves from society, but the service can be viewed with greater mobility since it is a door to door service to avoiding the obstacle and thus contributing to the inclusion social.
7. Market development for senior.
8. Promotion of autonomy people who have limited mobility.
9. Reduction of consumption fuel. Particularly important, in comparison with other means of transport due to use public transport rather than the individual.
10. Lower costs on future treatment and hospitalization related with the absence of treatment at present due to lack of ability to walk.

Direct Costs:

1. Initial Investment.
2. Cost of maintenance and operations management.
3. Disclosure.

Indirect benefits:

1. Reduced travel time for passengers of conventional public transport. People with reduced mobility no longer will need to embark, reducing so any delays in the paths.
2. Improved transportation system. The reduction of traffic and of congestion as it is a public transport service. Also of public transport gains due to the absence of people with reduced mobility that would be using another system and thus the public transport has better control over stop time.
3. Increased capacity of intermodal integration.
4. Improved quality of life in urban areas.
5. Recognition as a promoter of equality for all elements of society.
6. Reducing the release of polluting gases into the atmosphere. Decreasing:
 - a. The outbreak disease caused by greenhouse gases.
 - b. Disturbance or destruction of fauna or flora.
7. Reducing emissions of gases that increase the greenhouse effect.
8. Reduced loss of transshipment or delays in arrival at destination of passengers on public transport conventional due to loss of time caused by the people with reduced mobility.

Indirect cost:

1. Reduction of services that could be made by other systems. It is relevant to highlight that the loss of service that was provided by other entities such examples are the taxi drivers or firefighters, so this professionals would be without a large share of its revenue.
2. The absence of determined treatment usually involves an increase in the patient's pain, which can cause anxiety in the family and people closest.

The attribution or the determinations of monetary values to the different factors become important in decision making and for choosing a project in respect of others. The comparison taking into account the intangible factors usually makes the decision more fair, contributed equally to the benefit of society as a whole.

CONCLUSIONS AND FURTHER RESEARCH

The current collective passenger transport by road is not suitable to transport people with reduced mobility. In this sense, there is a need to develop a parallel market that can fill this gap. The problem arises because of the need to ensure the financial viability of the project, so that it can be difficult in the case of the present fare aiming to provide a system relatively accessible to your target market.

The decision to implement a project aimed to accomplish this objective should not be confined to the economic analysis, but should go a bit further, in order to well justify the support by the public agency. In the theoretical analysis of externalities, it is possible to see that there are important factors that are not accounted monetarily, but must be considered at time of evaluation. These factors have direct impact on society and are not transferred in a direct manner to the project. The main problem lies in the initial cost, but there is also a high the number of direct and indirect benefits that must be accounted for. The impact that the project has on society and the environment must be considered and analyzable so as to be supported by the public institutions.

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DEVELOPMENT OF A COST-BENEFIT MODEL FOR MICRO CHP SYSTEMS

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CHP system, Cost-benefit analysis.

ABSTRACT

In the last decade, new improvements on energy systems production have been conducted. The liberalization of the energy market, the search for alternative technologies using renewable energy sources, the sustainability of energy supply and the environmental issues are factors that emphasize the introduction of decentralized power generation systems.

The purpose of this work is to identify the variables that must be considered in developing an economic model to assess the viability of a new micro-cogeneration system for micro-scale applications. In the development of cost-benefit analysis, two types of variables should be considered: the internal variables that quantify and parameterize the operation and performance of the system; and external variables that evaluate the social and environmental impacts arising from the use of cogeneration technology.

The design of decentralized energy systems is usually carried out integrating technical and economic aspects. As a consequence, the assessment of CHP systems sustainability requires the analysis of operational cost-benefit analysis as well as the environmental and social impacts, which represent important external costs.

INTRODUCTION

Cogeneration or Combined Heat and Power (CHP) is defined as the simultaneous production of useful thermal and mechanical energy from a single primary energy source. These high efficiency decentralized systems have been applied to small and micro-scale level applications (residential and commercial services) where the cogeneration plant can supply both the power and the thermal needs of the buildings (Jackson, 2007; Cardona *et al.*, 2006; Alanne, 2010).

The evaluation of a CHP system is a complex and demanding task. Several approaches have been

conducted in order to better adjust their thermo-economic performance. Thermo-economic methodology combines economic and thermodynamic analysis by applying the concept of exergy cost which accounts for the quality of energy (Abusoglu and Kanoglu, 2009).

Numerous studies and theoretical approaches in the thermo-economic field have been developed to design and optimize thermal systems. Von Spakovsky and Evans, 1990; El-Sayed, 1989 and Valero *et al.*, 1994 developed methods that incorporate some key concepts of thermo-economics: sizing restriction through component costing equations, the integration of decomposition and large-scale optimization schemes, the identification of thermodynamic variables (power, mass rate, heat rate, enthalpy, entropy, heat loss, efficiency, heat exchanger effectiveness), the adaptation of thermo-economic models to non-linear programming problems and the development of methodologies related to exergy cost analysis. The most cited technologies for small and micro-cogeneration applications in these studies are the fuel cells, internal combustion engines and micro gas turbines.

Some authors established that the introduction of CHP system in the residential sector requires the development of compact, cost efficient and easily installed systems. Huangfu *et al.*, 2007, present a study in which an evaluation and analysis of a micro-scale combined cooling, heating and power system were performed. The economic efficiency of the system is discussed in terms of different criteria: payback period, initial costs, annual savings, annual profits, operating cost, interest rate calculation, system life time and net present value.

Sontag and Lange, 2003 presented a power-controlled CHP system with a photovoltaic plant for decentralized power generation coupled with solar thermal collectors. The cost effectiveness of the system is assessed based on annuity calculus by combining different options for the energy sources (wind and solar energy).

Pilavachi *et al.*, 2006 defend that the development, construction and operation of small and micro-CHP

systems must be evaluated according to economic, social and environmental aspects in an integrated way and the results of the evaluation should be compared by means of the sustainability scores.

Alanne *et al.*, 2010 in their studies, support that the condition for the economic viability of a micro-cogeneration system is that and lower fuel costs.

In the work of Lazzareto and Toffolo, 2004 the best option to optimize thermal systems considering single- or multi-objective optimization approaches is discussed. The study was performed using evolutionary algorithms to optimize the design parameters of the CGAM problem plant (see Valero *et al.*, 1994) defining a energy, economic and environment assessment model. The consideration of environmental consequences in thermal design aims to optimize energy conversion with the maximum efficiency at minimum cost and with the minimum environmental impact. The most important remark of this study is that, in the design of thermal systems, pollution damage costs should be included in the optimization model.

Gullí, 2006 presented a social cost-benefit analysis of small CHP distributed generation system. The analysis is based on the determination of internal (calculation of optimal electricity and fuel costs) and the external costs by applying the *ExternE* approach. The methodology of *ExternE* approach includes the weighting of the external impacts using quantitative procedures in order to transform these impacts into monetary units. The author developed a comparison between the centralized and the decentralized energy supply concluding that, despite the optimism about decentralized power production, their implementation in the residential sector does not represent a competitive solution.

In sum, the studies demonstrated that the optimization of thermal systems involves a multi-criteria parametrization in the selection of a cogeneration system for a specific application. CHP systems should be sized to maximize the cost savings from onsite use of waste heat and avoided electricity costs. The economics of CHP systems seems to be directly influenced by the fuel and electricity prices in the market. The performance of CHP technologies with respect to the environmental concerns depends on the total conversion efficiency that can be achieved. Its improved efficiency in fuel conversion reduces the amount of fuel burned for a given level of energy outputs and, as a consequence, the costs with the fuel are lower when compared with the conventional systems. This reduction in fuel consumption levels may represent a significant and competitive economic advantage, once the imports of fossil energy resources can also be reduced. Moreover, these energy savings achieved by a more efficient

technology also promotes the reduction of pollutant gas emissions to the environment.

Therefore, and based on the exhaustive literature review, this work will be focused on the identification of the most important variables to be considered in developing a model for economic evaluation of a cogeneration system for micro-scale applications. This preliminary study aims to be based on a cost-benefit analysis always considering the normative supporting framework in the Portuguese energy scenario.

PORTUGUESE FRAMEWORK FOR CHP

The European Directive 2004/8/EC defines “small-scale cogeneration” as the units with an installed capacity bellow 1 MWe, “micro-cogeneration unit” as the systems with a maximum capacity bellow 50 kWe, and indicates that member states may particularly facilitate these two classes of smaller size systems. This directive came into force in 2006 aiming the promotion of high-efficiency production of heat and power based on useful heat demand and Primary Energy Saving (PES). The main objective was to reaching a less restrictive framework for the installation of cogeneration systems and improve the revenues from its use. In addition, the European Energy Performance of Buildings Directive (EPBD) obliges all member states to ensure that, for new buildings with a floor area over 1000 m², the economic feasibility of alternative systems, such as decentralised energy supply systems based on CHP or renewable energy, is considered at the system design.

The flexibility of CHP systems are conducting to their dissemination in small and micro-scale applications.

Recently, the Directive 2010/31/EU introduced the philosophy that buildings should become energy producers and outlined a goal for 2020: the energy requirements of all the new buildings should be near to zero. It is expected that the rising costs of fossil resources and the future economic incentives associated with this legislation, will lead to a strong growth of CHP systems in the residential sector.

Consequently, the market for this kind of technology will suffer an increase for the home-sized cogenerations as well as small commercial buildings. This fact is due to the weight of the residential and services sector in the energy consumption. In the Portuguese scenario, the government has been promoting energy efficiency policies trying to reduce the greenhouse gas emissions due to the recent growth of electricity consumption, and so, cogeneration is a technology that has benefited from these political measures. In fact, since 2003, the electrical power production obtained through

cogeneration technologies is over 12% of total national electricity production (Moreira *et al.*, 2007).

In turn, the residential sector represented 16.8% of the total final energy consumption in the year of 2008, (Figure 1). These values show that the residential buildings are the third highest activity in final energy consumption in Portugal.

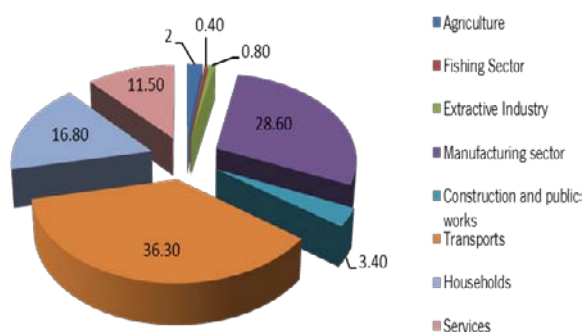


Figure1: Final Energy Consumption (%) by sector of economic activity in 2008 (INE, 2008).

Moreover, and according to Eurostat, Portugal is one of the countries of the European Union where electricity prices are higher, which favors micro-CHP systems implementation. Thus, CHP has a great potential that can be better exploited within the Portuguese framework.

MICRO-CHP MODEL DEVELOPMENT

The development of micro-CHP model aims the construction of an effective way to globally analyse a thermal system from the techno-economical point of view. The development of thermal systems models involve different steps which depend on technical and economical constraints. Figure 2 describes, schematically, the main steps in the process of developing a micro-CHP model.

The micro-CHP system sizing depends on the application requirements. This means that the system components have to be chosen according to the thermal and power demands of the consumer. The identification of end user consumption necessities has a great importance in the definition of technical characteristics of the CHP unit. The definition of energy consumption profiles is determinant in finding out the appropriate relationship between the power production and its consumption. So, for small scale applications, it is important to define if the system is to satisfy the energy needs of a single and/or multi-family residence; a commercial or an administrative building.

The evaluation of the energy consumptions is very important to minimize electricity demand from the network grid and maximize the efficiency of the CHP unit. The main idea in the process is the design of a CHP system that satisfies the energy requirements by a flexible adaptation to user consumption, also taking into account the tariffs of electrical power. It is also important to define the type of fuel and the tariff applied. This characterist is significant in the operational costs of the system. In fact, the variation of fuel and electricity prices may have an important impact in the cash flows from the CHP system operation.

A cost-benefit analysis can be performed to assess the economic evaluation of micro-CHP systems. The economic evaluation may be done making estimations about the variable and fixed costs for the new system and comparing them to the costs of a reference/conventional system. The fixed costs can be calculated according to the costs of micro-CHP system on a component level. The variable costs are the hardest to identify since they depend on system operational performance and so, a reasonable relationship must be achieved.

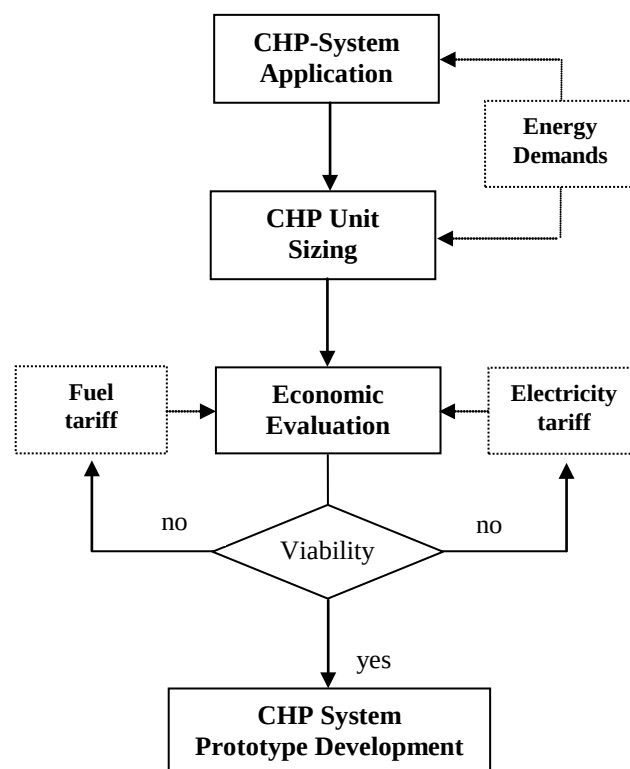


Figure 2: Representative diagram for the process of the development of a micro-CHP model.

COST-BENEFIT ANALYSIS

In the development of cost-benefit analysis, two types of variables should be considered: the internal variables that quantify and parameterize the operation of the cogeneration system; and external variables that perform a cost-benefit analysis of social and environmental aspects arising from the use of cogeneration technology. Combining internal and external costs in the development of an economic model provides a total cost evaluation of this decentralized energy systems. Then, the results of this evaluation may be compared with the total costs involved in the centralized energy supply in order to achieve the benefits of decentralised technologies.

Internal Analysis

The internal cost-benefit analysis of micro-CHP systems is directly related with system dimensioning, the technological choice and the assumed energy demands. The operational result from the Internal Cost-Benefit (I_{CB}) analysis results may be calculated as the difference between the Revenues (R) and the total Costs (C).

$$I_{CB} = \sum \text{Revenues} - \sum \text{Costs} \quad (1)$$

In terms of revenues, one of the most advantages of micro-CHP systems is the possibility of selling the surplus energy to the power distribution network due to the “producer-consumer” profile contemplated by the legal framework. The income (R_{sell}) from selling power to the net grid represents the power produced by the CHP system (E_{prod}) multiplied by the selling price (p_{sell}). This relation is expressed by the Equation (2).

$$R_{sell} = E_{prod} p_{sell} \quad (2)$$

Under the current legal framework in Portugal, the selling price of electricity to the grid of the micro-cogeneration energy systems (with the exception of biomass micro-cogeneration systems) is equal to the purchase prices of the tariff applicable to the consumer. So the owner of the CHP system can choose whether to sell all the power produced to the network.

When it is compared the combined production by the micro-CHP systems with the conventional power generation (Figure 3), it is clear that it is not required a full separate system (typically a boiler) to produce heat. In fact, one of the most important benefits of micro-CHP systems over conventional ones is related to their capacity to use the waste heat from electrical power generation (Lazzaretto and Toffolo, 2004).

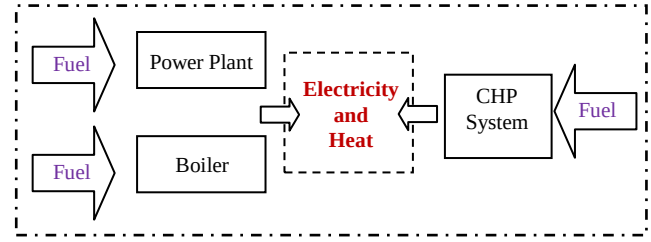


Figure 3: Comparison between separate production of electricity and heat and power production of cogeneration.

Thus, as an economic advantage, it can be considered in the model the avoided cost (C_a) to produce the same useful thermal energy by the CHP system (H_{CHP}) to fulfill thermal needs of the building (space heating or hot water).

$$C_a = \left(p_{fuel} \left(\frac{H_{CHP}}{\eta_{boiler}} \right) \right) \quad (3)$$

where p_{fuel} represents the fuel price for the boiler operation and η_{boiler} is the efficiency of reference for conventional boilers.

Another benefit from using micro-CHP systems is the reduction of transmission and distribution losses, which should also be considered in the economic balance.

In terms of the economical cost equations, they depend on the physical considerations of the system, operating performance, fuel and market prices fluctuations. So, in the development of this generalist model, the following costs may be considered:

- Purchase cost of each component of micro-CHP system, which corresponds to the initial investment (C_{CHP});
- Costs with the fuel for the micro-CHP unit operation (C_{fuel});
- Costs with power imported from the grid for starting the CHP system (C_{Egrid}).
- Maintenance Costs (C_m);
- Costs for the acquisition of a backup boiler (C_{bb}) when the system is not able to fulfill the thermal needs.

Therefore, the operational result from the Internal Cost-Benefit analysis may be defined as:

$$I_{CB} = (R_{sell} + C_a) - (C_{CHP} + C_{fuel} + C_m + C_{Egrid} + C_{bb}) \quad (4)$$

The critical step in the internal cost calculation is the simulation of prices of electricity and fuel taking into account that the energy demands varies significantly over the time, and so, it is important to establish the analysis period for economic study.

In addition to this operational analysis, it is important to consider some aspects that differentiate the cogeneration systems from the centralized energy production and which can be relevant in cost-benefit analysis. Cogeneration systems reduce the imports of the fossil resources due to more efficient fuel conversion, which represents a gain not only for the CHP system owner but also for the economic balance of our country.

External Analysis

The external cost-benefit analysis of the energy conversion systems represents a complex process.

Energy conversion cause substantial environmental and human health damages. The stipulation of those effects conducted to the emergence of the externality concept or external costs. When a social or economic activity have an impact causing damage, that fact imposes an external cost (Gullí, 2006; Ren and Gao, 2010).

With respect to cogeneration, the outcomes of the energy conversion process are not only the mechanical and thermal energy, but also pollutant emissions. The concept of external damage costs has been used to weigh the contribution of gas emissions in the environmental impact as well as its economic consequences. The determination of external costs, based on the *ExternE* methodology, is a sequential process and include the following steps: first of all it is required to quantify the pollutant emissions for each phase of the fuel cycle lifetime; the second step is the simulation of the dispersion of pollutants (for instance, the concentration of pollutant particules in the atmosphere); the identification of the receptors and, finally, the calculation of respective impact (Gullí, 2006). However, this process is not so simple to implement: the determination of a function able to describe the dose-response of pollutant agents and its monetary valuation is difficult to achieve.

This approach may represent a good approximation to determine the damages from pollutant emissions and the damage would be quantified as an “*energy footprint*” considering the economic valuation of pollution concentration (Gullí, 2006).

Obviously, the most assertive methodology is to compare the costs and the benefits of environmental

damage in a cost benefit analysis, but a *cost effectiveness* analysis is easier to perform. For instance, when the only pollutant considered is the CO₂ production, its easier to measure the pollutant damage based on the reduction of gas emissions which is proportional to the reduction of fuel consumption of CHP system.

So, a *cost effectiveness* analysis is probably a simplest way to determine externalities. In this specific context, the objective is monetarise the reduction of the gas emissions. Thus, this approach may represent a valuable alternative to measure the external benefits: achieve the highest valuation for the environmental benefits.

$$Environmental\ Benefit = \frac{Bonification}{Pollutant\ Emissions} \quad (5)$$

In terms of external analysis, it is also important to emphasize the qualitative/subjective aspects arising from the use of cogeneration systems that implement new, efficient and cleaner technologies such as the visual impacts or the appreciation for using renewable energy resources.

INVESTMENT CRITERIA FOR CHP SYSTEMS

The economic optimization in the design of CHP systems may be based on the examination of investment criteria for project selection. Prior to the analysis of economic criteria, it is necessary to define two important aspects: the life time of the project analysis and the definition of the minimum attractive rate of the return. An assertive determination of the minimum attractive rate is decisive because it influences the result of the economic evaluation. For instance, Biezma and San Cristóbal (2006) presented different techniques to perform a comparison of CHP systems. This authors considered a lifetime of 10 years for the CHP unit and an minimum attractive rate of 6%.

Numerous criteria is available and the methods used in cogeneration systems selection can be categorized according to the information that each one provides about the project:

The *NPV methods* are used in capital budgeting to analyse the cash flows that an investment or a project will yield. Four economic criteria can be calculated: the Present Worth (PW) and Future Worth (FW) which give the cash flows of a project to one equivalent present and future data, respectively; the Annual Worth (AW) that converts all cash flows to a series of equal cash flows for the *n* number of years of the project lifetime; and the Capitalized Worth (CW) that represents the present worth evaluated over an infinite lenght of time.

Concerning these methods, a project is accepted if the criteria has a positive value. The limitation of the NPV methods is a fair comparison can be made only when NPV values represent costs associated with equal service and assumes constant attractive rate throughout the analysis period.

The use of *Rate of Return methods* imply a positive present worth. These methods include the Internal Rate of Return (IRR), the External Rate of Return (ERR) and the Growth Rate of Return. The IRR is the rate that equates the present value of a project's cash outflow with the present value of its cash inflow. In other words, that interest rate for which the present value of a project is equal to zero. The ERR is a modified IRR that calculates the interest rate (i) for which the incorporation of specific reinvestment (future worth) is considered. The Growth Rate of Return calculates a project's rate of return at any instance of the period analysis. The reliability of this method is questionable once depending on the year of the analysis, two projects may be more appellative in different years.

The *Ratio methods* includes the premium worth percentage which returns the profit percentage obtained through the ratio of PW and the investment; the benefit/cost ratio, attempting to identify the relationship between the cost and benefits of a proposed project; and the profit to investment ratio which measures the total undiscounted profitability of a project investment.

The *Payback Period methods* returns the number of the years required to recover the amount of capital invested in the project. The main disadvantages of these methods are related to the fact that it ignores any benefits that occurs after the payback period, not measuring the project's profitability. In addition it does not take into account the time value of the money.

All these economic evaluation methods provide valuable information about the projects. However, the NPV, IRR and the payback period indicators are the more common criteria used to evaluate the economic optimization of CHP systems and the three generally used to accept or reject a project (Biezma and San Cristóbal, 2006; Luz-Silveira *et al*, 2002). Thus, the design and of a preliminary model for the economic evaluation should also consider a project balance where the investor determines the amount of positive and/or negative receipts at the end of project time period (Abecassis and Cabral, 1982; Alanne *et al*, 2010).

CONCLUSIONS AND FUTURE RESEARCH

The sustainability of a CHP system may be performed as a multi-criteria evaluation method measuring its performance in relation to economic, social and

environmental aspects. The installation, fuel, electricity and heat costs are economic variables that have to be optimized considering the market, energy price fluctuations and acquisition investments. The efficiency of the systems has not only an economic impact but also environmental and social effects. The impact of externalities in techno-economic evaluation is quiet difficult to measure. Therefore it is important to convert those externalities into quantitative units in order to better assess their weight in thermo-economic model.

According to various reviewed studies, the effectiveness in introducing small scale decentralized, specially in the residential sector raise some doubts. The increased overall efficiencies and the primary energy saving may be not sufficient to counterweight the investment costs. In otherwise, high emphasis on environmental effects and the implementation of environmental policies focused on the reduction of greenhouse gas emissions and the bonification for using renewable energy sources may strongly increase the micro-CHP systems competitiveness.

In the future work, the objective is the definition of a cost-benefit model applied to a cogeneration system for a micro-scale application. The system that is intended to be model is based on Stirling engine technology combined with a solar collector by proposing the use of a renewable energy source, the solar energy. The model to develop for the economic evaluation can consider the initial investment cost spreading across the lifetime of the system, aiming to account for the time value of the money. The determination of the project cash flows should also consider an interest rate that comprises the risk associated to the investment.

One important aspect to study is related to the estimation of the salvage value for the CHP system. After defining the model variables, a sensitivity analysis can be performed in order to adjust the parameters and assess their reliability for the proposed project.

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COST-BENEFIT ANALYSIS IN OCCUPATIONAL HEALTH AND SAFETY

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KEYWORDS

Cost-Benefit Analysis, Occupational Health and Safety, Delphi Methodology

ABSTRACT

The implementation of preventive and corrective measures within Occupational Health and Safety (OHS) lacks a proper systematic economic evaluation that allows to compare alternatives and to understand the impact of each of them. Firstly, there should be a financial evaluation of the measures considering costs and income for the organization resulting from the implementation of identified measures. However, it is also important to perform an analysis of the impact of each measure in society, in other words, to measure the involved externalities. The measures taken by an organization to prevent risks usually have an indirect positive effect (positive externality) in society, while not taking any action, compared to the cost they represent for the organization, can have important negative effects to society (negative externality).

It follows that these different economic effects (for the organization and society) should be duly considered in decision making on occupational health and safety. This paper discusses the use of cost-benefit analysis related to Occupational Health and Safety. An exploratory qualitative study is proposed, considering the application of the Delphi methodology.

INTRODUCTION

According to ISO/IEC 31010 (2009), the cost/benefit analysis can be used for risk assessment. In this case, expected total costs are weighted against the total expected benefits in order to choose the best, or most profitable, option.

Evaluation and Risk Analysis in OHS

The Occupational Health and Safety (OHS) management system can be regarded as part of the management system of an organization used to develop and implement the OHS policy and manage the related risks (OHSAS 18001:2007). Risk management is considered as including the risk assessment and control, comprising the systematic application of management policies, procedures and work practices to analyse,

assess and control risk (Roxo, 2004). Although risk assessment is a legal obligation, in terms of methodology there are no strict rules on how this should be done. Roxo (2004) considers that Risk Assessment is nothing more than a dynamic process, conducted in workplaces, in order to detect the components therein, capable of causing damage(s) to the exposed employee(s). It is a process that brings a dual purpose: a) estimating the severity (magnitude) of a particular risk and b) obtaining the needed information for an appropriate decision-making, including information on the need and type of preventive measures to be taken. In the opinion of Roxo (2004), Risk Assessment should include two steps: a) risk analysis, which aims to determine the magnitude of risk and b) risk evaluation, which aims to evaluate the significance of the assumed risk.

If a risk assessment (identification, estimation and evaluation) determines that a specific risk is not acceptable - acceptable risk is a risk that has been reduced to a level that can be tolerated by the organization and taking into account their legal obligations and its own OHS policy according to OHSAS 18001 (2007), then it is necessary to proceed to the set of actions to control risk. This refers to processes of decision / action for the management and risk reduction, its implementation and periodic review, by using the results of risk assessment as an input. Typically, organizations make a more or less detailed evaluation of the monetary impact (positive or negative) on the actual organization of each decision/action to implement. Any preventive measure is translated into a cost and the real profitability can only be confirmed through an appropriate cost-benefit analysis (Miguel, 2010). Literature on Occupational Health and Safety presents several approaches that assess the impact of these measures particularly in terms of cost analysis and the level of cost-benefit analysis.

Hokstad and Steiro (2006) have developed a comprehensive strategy for risk assessment and setting of priorities for risk regulations, in which they approached the support of planning and priority setting for risk control.

For some risks, particularly those threatening human life or implying damage to the environment, the ALARP (as low as reasonable practicable) can be applied. This methodology divides risks into three bands according to

two levels of risk: a level above which the risks are not acceptable and thus should not exist, except in extraordinary circumstances and a level below which the risks are insignificant and need only to be monitored to ensure they remain low. Accordingly, there is a central band, in which the risks should be kept as low as reasonably practicable. At this level of risk, a rigorous analysis of costs and benefits can be applied. However, when risk level are close to the intolerable, the expectation of the ALARP principle is that treatment will occur unless the treatment costs are grossly disproportionate to the benefits obtained.

Cost Analysis in OHS

During the middle of the last century, Heinrich (1959) drew attention to the high costs of occupational accidents in American companies. This author considered the division of accident costs in to two types of costs, direct and indirect. The former include: compensation, health care spending and other costs related to management and may be represented by the insurance cost, while the latter include: the time lost by injured workers and others, the time used in determining the causes of the accident, the time required for selecting and training a replacement for the injured, production losses, losses due to repairs, losses due to defective products, losses on the level of efficiency and performance when the injured worker returns to work, commercial losses and losses resulting from the deterioration of the company's external image - ISO/IEC 31010 (2009). Heinrich established a linear relationship of 1:4 for direct costs and indirect costs respectively, as referred by Miguel (2010).

When the result of a project cannot be measured in monetary units, analysts adopt the cost-effectiveness analysis (CEA). The cost-effectiveness analysis is an evaluation technique used to select a project that will bring the lowest production cost of a certain product or choose the project that will lead to maximum production at a given cost. According to EVALSED (2009), the cost-effectiveness analysis (CEA) is a tool that can contribute to an efficient application of resources and investments in sectors where benefits are difficult to assess. This approach is useful to identify and select alternative projects with the same objectives (quantified in physical terms). The CEA can identify an alternative project that for a given level of expected results, minimizes the actual cost or, for a specific cost, maximizes the level of expected results. For example, the evaluator can compare the different projects by means of simple linear relations result/cost. Typically, the assumption is that a benefit or desired result can be achieved through different alternative ways. Thus, in this approach are usually only considered the costs and the cheapest way to get to achieve the desired benefit.

However, a financial assessment of the alternatives can be done if a monetary value can be assigned to all costs and tangible and intangible benefits. Generally, there is

an initial cost and benefits that arise after a long period, making it necessary to update these cash flows using a discount rate appropriate for the company, referring to the present, so that a valid comparison can be obtained. Thus, all costs and benefits are expressed in present value. The present value of all costs and benefits for all stakeholders can be combined to produce a net present value (NPV). A positive NPV means that the action / project is beneficial, which means that the income generated outweigh the costs incurred. If there is uncertainty about the level of costs and benefits, one or both terms may be weighted according to their probabilities. This analysis can be expressed quantitatively as a net present value (NPV), internal rate of return (IRR) or as the ratio between the present value of benefits and present value of costs.

Cost-Benefit Analysis

The cost-benefit analysis (CBA) is used to determine whether a project is feasible from the standpoint of social welfare by the sum of the costs and benefits, discounted over time (EVALSED, 2009).

The CBA usually accompanies a feasibility study (technical, financial, legal, organizational) of the project and is its final synthesis. According to EVALSED (2009) CBA is characterized by five main stages: 1) project identification, technical analysis and demand, 2) financial analysis, 3) correction of tax effects, 4) calculation of positive and negative externalities, 5) market prices to shadow prices and 6) calculating the economic profitability of the project.

The financial analysis is the departure point for a subsequent economic analysis. It provides all the needed data in terms of inputs, outputs, their relative prices and how these are distributed predictably over time. The financial analysis can be performed using measures such as the net present value, the internal rate of return and the payback period. The financial analysis from the viewpoint of the private investor includes some items, such as income taxes, which do not represent a social benefit or a cost but a transfer from one social group to another. There are other examples of tax effects in the case of subsidies, social contributions considered in the cost of manpower and the effects of taxes on prices of inputs and outputs. In assessing the "appropriateness", the public operator also takes into account the externalities generated by the project. Externalities consist of social costs or benefits that manifest themselves beyond the realm of the project and influence the welfare of third parties without any monetary compensation. A final correction is made by calculating the appropriate conversion factors, which multiplied by market price estimate the value of shadow prices. This correction is necessary because markets are imperfect and the market prices do not always reflect the opportunity cost of an asset. If prices are distorted, they are not an appropriate indicator of the well-being.

In order to fix the market prices of inputs and outputs, the following elements are used: the marginal cost, for non-traded goods such as land, services, local transport, etc.; the price "outside the country" for tradables, the conventional conversion factor for small non-tradable goods. In order to measure the economic convenience, after time rebate with a social discount rate (generally different from the financial rate), it is now necessary to calculate the net present value and internal rate of return, following the same methodology used in financial analysis (calculating the present net value NPV and calculation of the net internal rate of return IRR). It is expected that the economic internal rate of return exceeds the rate of financial return. If this is not the case, the project will be more convenient for a private investor than for a public operator (unless there are considerable social benefits that are not quantifiable in monetary terms).

A cost-benefit analysis should take into account the costs throughout the life cycle of the subject under study, involving both economic costs and benefits "accountable" and the impacts are not "accountable", known in literature as externalities (Queiroz, 1999).

Externalities

According to Rebitzer et al. (2004), externalities can be divided into the internalized externalities and the not internalized externalities, as it is important to distinguish the variant environmental and social from the cost of the environmental life cycle. According to Mann and Wüstemann (2008), there are textbooks of economy that suggest that externalities must be internalized in order to achieve a Pareto optimum. According to Barros (2009), an allocation of resources is preferable to any other if it leads to the improvement of the welfare of an individual, without diminishing the welfare of other individuals within the same society. Thus, from the moment when it is not possible to improve the welfare of an individual without diminishing the welfare of other individuals that allocation of resources is Pareto optimal.

Externalities consist of social costs or benefits that manifest themselves beyond the realm of the project and influence the welfare of third parties without any monetary compensation (EVALSED, 2009). Van Beukering et al. (1998) consider that an externality occurs when an economic decision has an impact on the welfare of another economic agent not directly involved in the process, resulting from the fact that the possibility of impact has not been properly addressed at the planning stage. In general, an externality is present when the welfare function (Y) of some economic agent (utility or profit) includes real variables whose values are chosen directly by others (X), without special attention to the effect on the welfare of agent Y that they affect. Where the project needs or deserves an evaluation by a public entity, the externalities generated are taken into consideration. However, the evaluation of projects of a private nature does not consider the effects

on third parties arising from associated externalities. Indeed, the externalities generated by the projects are in many cases difficult to quantify. This is the case, for example, of calculations related to the "value" of human life.

For Varian (1992), the definition of externality is that the action of an agent directly affects the living conditions of another agent. Externalities can also be defined as: "the uncompensated impact of actions of one person over the welfare of a spectator" (Mann and Wüstemann, 2008). The focus on human welfare, primarily used as a synonym for human utility, is due to the traditional utilitarianism of economics.

There are several types of externalities, positive or negative, depending on the fact that its effects on third parties are harmful or beneficial, and externalities of production or consumption, when they arise from the production or consumption of certain goods (Sousa, 2000). According to Barros (2009), externalities may also be positive (external benefits) or negative (external costs) and occur both at production or consumption. An example of positive externality in consumption is the case of two neighbours in which one decides to build a garden; if both are enjoying the garden then the one who built the garden produced to the other a positive externality. Example of negative externality in consumption: in a closed room where some people smoke and others do not, those who do not smoke are forced to breathe smoke, having a negative externality.

The concept of externality can and should be applied to the area of OHS, namely through the implementation of a cost-benefit analysis. When an organization performs a risk analysis integrated in the assessment of its OHS management system, several steps are suggested to solve the identified resolve the situations. Usually the organization makes a detailed analysis of the monetary impact (positive or negative) for the organization of each considered measures. However, it is also important to perform an analysis of the impact of each measure in society, i.e., to measure the involved externalities. The measures taken by an organization in risk prevention may have an indirect positive effect (positive externality) in society, while no action, due to the costs for the organization, may have significant negative effect for society (negative externality). It follows that these effects should be duly considered in decision making.

This paper aims at discussing the use of the cost-benefit analysis within the OHS domain. With this purpose, a qualitative exploratory study is proposed, using the application of the Delphi methodology. In this study it is intended to get some input from an expert panel by conducting a series of questionnaires in order to determine the most important factors to consider in the cost-benefit analysis on OHS.

DELPHI METHODOLOGY

The Delphi methodology is an exploratory study that allows gathering the views of the considered

participants, typically a panel of experts on the study domain, which is called the Delphi panel. This process is carry out by conducting a series of questionnaires on a specific subject. In this study, the subject to be examined is the application of "Cost-Benefit in OHS". Some of the characteristics of the Delphi methodology are the anonymity of the participants, the statistical representation of the distribution of results and the use of the feedback from the group to review the answers in in a later round. Table 1 presents the main steps of the Delphi methodology, which is carried out during several consecutive rounds.

The contents/topics in the questionnaire are scored according to their degree of importance, e.g. on a scale of 1 to 5; 5 for a "very high" importance and 1 for a "very low" importance. New contents, comments or suggestions may be suggested at each round, and that should be taken into account in the following rounds. The variables are discrete, categorical and ordinal qualitative type. Usually the following sample characteristics are obtained: median, mode and interquartile range.

The interquartile range (IQR) is a measure of the dispersion and the median is the obtained value for 50% of observations. Thus, an IQR of 1 or less means that more than 50% of all opinions fall on a given point on the scale (von der Gracht and Darkow, 2010). After each round, a set of statistical measures are applied for each subjective estimate associated with each content/topic individually considered: median, mode, arithmetic mean; interquartile amplitude and range between quartiles to offer, iteratively and to each participant, the statistical feedback of the group.

It is intended to compare a set of ratings given by the experts, upon the whole content/topics in order to understand if there is a consensus among the experts about the given answers, since the choice is limited to the number of factors corresponding to the levels of classification proposed. The consensus is indicated by the distance between the first and third quartile and the median value. The median is simply the value that lies in the middle of the ordered set of values, from the lowest to the highest. Thus, there must be an order relation of the values, so the median can be calculated both for ordinal variables and for the pure quantitative (PSP, 2011). The median indicates the degree of support group for each factor and if it is high, it appears that there is a great support from the group. Of course, the median is also the second quartile or the 50th percentile (PSP, 2011).

The presentation of the quartiles allows an assessment of the degree of convergence of the answers. The quartiles are used to help the measurement the variability or dispersion of the observed data. The first quartile is such a value that the variable number of observations to lower values is 25% and above is 75%, e.g., the first quartile (Q1) refers to 25% of agreement among experts and the third quartile (Q3) refers to 75% of agreement. The interquartile range is the difference between the third quartile and first quartile (Q3-Q1). The interquartile range is the difference between the first and third quartile in the range where it lies 50% of the core values (PSP, 2011). The greater the amplitude, the greater the dispersion in the data, thus a small interquartile range indicates a small variation in the responses of panel members, which shows that they

Table 1 – Main steps of the Delphi methodology

Step	Description
Experts selection	In the selection of experts a balanced distribution of elements should be seeked, making use of universities, research institutes, industries and other sectors of society. The quality of the result depends primarily on the study participants. A panel from 10 to 15 specialists is considered sufficient to generate relevant information (Skulmoski et al., 2007).
Completing the questionnaire	The questionnaire is available by post or by email; a form can be used and the answers are entered into a spreadsheet.
Statistics analysis of results	After a pre-defined period, the team collects the data and complete the corresponding statistical analysis. After the analysis of the 1st round, the coordination team must decide on the need to incorporate new issues in the 2nd round, which is quite common. After each round, a set of statistical measures are applied for each subjective estimate associated with each content/topic, namely: the median, the mode, the mean and interquartile range; these measures will give some feedback to each participant about the group's opinion. The median and interquartile range are the most used statistical feedback of the group.
Preparation of the questionnaire for the second round	The second round of the Delphi questionnaire must present the results of the first questionnaire, allowing each respondent to review the initial answer by considering the group's results. The goal is the convergence of results. At least two rounds are essential according to the Delphi methodology; there are only rare examples of studies with more than three rounds of the questionnaire.
General conclusions and final report	The final results are processed from the consensus generated by the group. The results may be qualitative in the form of reports, conclusions, etc. and quantitative (subjective probabilities, mean, median, interquartile range, etc.).

have reached a consensus. An interquartile range of 0 indicates a perfect consensus among panel members. In the Delphi method, the required type and level of consensus should be defined in advance. A consensus means that the degree of convergence of individual estimates is achieved when opinions exhibit an acceptable degree of similarity. There are many criteria to establish the moment they reached a consensus, these can be: a) no topic be accepted if it is not adopted by x% of the participants in the last round, b) x% of the topics receiving the most votes after Y rounds; c) only the topics that have received an average score greater than or equal to 3 on the Likert scale (1-5) are adopted, d) only the topics that have received at least rating 2 in a scale 1-3 by 51% of participants are adopted, and e) topics that have been rejected by at least x% of participants are rejected (Oliveira, 2008).

QUESTIONNAIRE

The design of a questionnaire must be preceded by certain prerequisites. First, the focus of the study must be carefully defined. Second, the study objectives must be translated into measurable factors that contribute to that focus. Third, the researcher must ensure that he or she is well competent in the topic. Finally, it must be consistently administered (Glasow, 2005). There are some rules for designing good questions in a questionnaire. As stated by Fowler and Floyd (1995, p. 3) "...a good question is one that produces answers that are reliable and valid measures of something we want to describe".

In this case, the questionnaire is divided into six distinct parts. The questionnaire has a total of 50 questions. Section 2, occupational risk assessment, is composed by 13 questions. Section 3 has 10 questions covering issues on cost and benefits analysis of occupational risks. Sections 4, 5 and 6 will permit to collect the opinion of the specialists on the relevance of financial assessment, economic analysis, cost-benefit analysis and externalities to understand the implementation of the measures identified under occupational risk assessments. These three groups sum a total of 25 questions. Table 2 presents the content/topics in each part of the questionnaire.

Next subsections present all the questions of this questionnaire. The questionnaire will be complemented by a document where all main concepts are briefly explained; in some cases simple examples are given. All questions are measured with a Likert scale from 5 for a "very high" importance to 1 for a "very low" importance. A specialist will be available for clarifications by email.

Section 2. Occupational Risk Assessment

How important are the following items for the Occupational Risk Assessment?

1. The separation of accident costs in terms of direct and indirect costs
2. The rigorous and comprehensive assessment of the direct costs of workplace accidents
3. Using a large number of items in calculating the costs of workplace accidents
4. The standardization of the main cost items of workplace accidents which can be applied in different situations and companies
5. The rigorous calculation of indirect costs of workplace accidents
6. Using the insurance premium as an estimate of the direct costs
7. Calculating indirect costs from direct costs assuming a certain ratio of proportionality (e.g. 4 to 1)
8. Some indirect costs can and should be calculated or estimated by substituting or reducing the application of the proportionality relation
9. Using economic valuation of risk assessment and control of occupational hazards
10. Using economic valuation of the risks of preventive measures to take
11. Using a simple analysis of the monetary impact of each decision/action to implement in the organization
12. Using the ALARP principle in the evaluation and control of risks
13. To adopt an analysis focused only on costs and benefits of mid-level risk according to ALARP classification

Table 2 – Topics addressed in the developed questionnaire on Cost-Benefit Analysis in OHS

Sections	Contents/Topics
1.Introduction	Aims of the study; Structure of the questionnaire; Methodology
2.Occupational Risk Assessment	Risk Analysis; Risk Assessment; Risk Control
3. Costs and Benefits Analysis of Occupational Risks	Cost of measures; Tangible benefits; Cost-minimization; Cost-effectiveness; Cost-utility; Costs used; Cost-benefit analysis
4. Financial Assessment (for the company)	Simple Payback; Discounted Payback; IRR; NPV; Annualized value; ROI
5. Economic Evaluation (for the society)	Tax adjustments; Shadow prices; Correction of externalities; Opportunity cost; Economic NPV; IRR economic
6. Externalities	Positive; Negative; Consumption; Production; Cash Benefits; Technology; Social

Section 3. Costs and Benefits Analysis of Occupational Risks

How important are the following approaches in the Analysis of Costs and Benefits of Occupational Risk?

1. Measuring in monetary units the costs of preventive measures which could be undertaken
2. Measuring in monetary units the tangible benefits of preventive measures which could be undertaken
3. Adopting a cost-minimization analysis (CMA)
4. Adopting a cost-utility analysis (CUA)
5. Adopting a cost-effectiveness analysis (CEA)
6. Comparing alternatives with equal efficacy in order to select the lowest cost solution
7. To consider that interventions have impact in terms of morbidity and mortality
8. The use of measures expressed in terms of quality adjusted life years (QALY)
9. The use of natural units such as "life years gained"
10. To analyse the incremental cost of achieving a better outcome computing a cost per unit effect

Section 4. Financial Assessment (from the company's perspective)

How important are the following aspects for the Financial Evaluation (from the company's perspective) of the measures identified under the Occupational Risk Assessment?

1. Considering the future cash flows in the evaluation of preventive measures which can be undertaken
2. Actualizing future cash flows using an average discount rate for the sector instead of a discount rate calculated for each case
3. The implementation of the measures which have a positive net present value (NPV)
4. The implementation of the measures which have a ratio between the present value of benefits and the present value of costs above a certain value (e.g. benefits/costs > 1,5)
5. The implementation of the measures which have a payback or capital recovery time below a certain threshold (e.g. 3 years)
6. Calculating the Return on Investment (ROI) of the preventive measures which can be undertaken

Section 5. Economic Evaluation (for the society)

How important are the following aspects for the Economic Evaluation (in terms of society – i.e. considering externalities) of the measures identified under the Occupational Risk Assessment?

1. To undertake a cost-benefit analysis (CBA) of the measures, e.g. assess the impact of its implementation from the standpoint of social welfare
2. To calculate a social discount rate
3. To calculate the economic NPV
4. To calculate the economic Internal Rate of Return

5. The correction of tax effects in the CBA of the measures
6. The calculation of positive and negative externalities in the CBA of the measures
7. The calculation of shadow prices in the CBA of the measures
8. The use of conversion factors for calculating shadow prices in the CBA of the measures
9. The CBA is important for the evaluation of occupational hazards from the company's perspective
10. The CBA is important for industry associations to evaluate occupational hazards from the industry's perspective
11. The CBA is important for public institutions to evaluate occupational hazards from the society perspective
12. The CBA can be used to prioritize measures to be implemented considering their impact on business and society
13. The CBA can be used to promote, support, subsidize or to legislate in a reasonable manner the measures of prevention of occupational hazards

Section 6. Externalities

How important are the following aspects in the Evaluation of Externalities for a proper analysis of Costs and Benefits of Occupational Risk?

1. Analyzing the positive externalities
2. Analyzing the negative externalities
3. Analyzing externalities of consumption
4. Analyzing the externalities of production
5. Analyzing the technological externalities
6. Analyzing the social externalities

CONCLUSIONS AND FURTHER RESEARCH

Given the apparent lack of studies on the use of cost-benefit analysis related to OHS, in this paper it is proposed an exploratory qualitative study applying the Delphi methodology. This methodology allows the assessment of the views of experts, by conducting a series of questionnaires on the subject, where the final results are processed from the consensus generated by the group. According to Geist (2010), the Delphi method can be used to determine important issues such as a precursor to the development of a search. For Geist (2010) it is important to send daily reminders to specialists during the whole process, to obtain higher response rates. For some authors, e.g. Skulmoski et al. (2007), the method of data analysis and reporting results are directly related to the type of questions used in the Delphi questionnaire. The authors note the importance of applying appropriate analysis techniques and the inclusion of analysis of results sorted according to areas of agreement and disagreement.

The Delphi method allows for anonymity, and all opinions have equal weight, avoiding the problem of

dominant personalities. Moreover, participants need not to be gathered in one place and at the same time. When research questions can be addressed through the use of questionnaires and the research purpose is mainly exploratory, the Delphi methodology is an excellent research tool, mainly because its application is relatively inexpensive and allow a fast way to acquire data through an effective and scientifically valid way. In contrast, the disadvantage of this approach is that it is a laborious and time-consuming technique, as participants need to be able to express their views, it presents a typical low internal consistency and reliability of opinions among experts and therefore a low reproducibility of the predictions based on the results. There must be a sensitivity of the results in relation to the ambiguity and reactivity of respondents in the questionnaires used to collect information and it is difficult to assess the degree of knowledge possessed by the participating experts.

Thus, a questionnaire was developed with the purpose of apply it to several experts; it is expected that with the planned three rounds it may be possible to obtain important conclusions and to have a better understanding of the importance of the cost-benefit analysis application in the OHS domain. Through the questionnaire it is expected to get a response rate of at least 75%, although it is desired that the response rate can be ranged between 85% and 90%.

The opinions of the expert panel will clarify what issues are important to consider in the development and application of cost-benefit analysis on OHS. In fact, the implementation of corrective and preventive actions under OHS requires a proper and systematic economic evaluation, in order to compare alternatives and understand the impact of each of them. For this, it is important to consider not only the costs and benefits for the organization but also the so-called externalities, which correspond to the impact of each measure in the whole society.

Thus, the current paper, with the aim at developing the subject of cost-benefit analysis related to OHS, proposes a qualitative exploratory study by using the application of the Delphi methodology. Accordingly, a questionnaire, which will be sent to several experts, has been developed. It is expected that after the planned three rounds it will be possible to obtain some important conclusions and a better understanding of the importance of the application of the cost-benefit analysis in the OHS domain.

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SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT - THEORETICAL CONTRIBUTIONS

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KEYWORDS

Project analysis; Evaluation; Social and environmental

ABSTRACT

When we have to make an investment decision, we have to consider social and environmental factors that can bring some doubts about the project. We analyse not only which social and environmental characteristics to assess, but also identify main risks and show how to mitigate them. In addition, we support the idea that both areas have to be analysed at the beginning of the project and that it has to be done at the time investors analyse other factors, in particular technical issues.

INTRODUCTION

In capital budgeting, the traditional approach only takes into consideration financial aspects, undervaluing any others that may influence project viability. However, basing an investment decision only on financial criteria may lead to inadequate decisions. Complex decision-making cannot be based solely on financial criteria.

The investment decision-making process is complex and goes beyond financial aspects. Financial techniques should only be used as a guide and other factors should be taken into account, since they may influence the analysis of uncertainty. Therefore, even if financial conditions are very favorable, neglecting additional qualitative information may cause serious problems. The difficulties inherent to the evaluation of these aspects are related to their intangible nature and to the difficulty in measuring them, making their analysis strongly subjective. Investment decisions should include subjective considerations, particularly when it is difficult to quantify the costs and benefits associated with projects. Non-financial evaluation techniques supply information about less tangible factors and are expected to be able to identify competitive advantages to a project that financial techniques cannot capture (Chen, 1995). This way, financial projections may be improved and made less risky when non-financial aspects are considered in project appraisal.

Lopes and Flavell (1998), Love et al. (2002) and Datta and Mukherjee (2001) show evidence that supports the importance of analysing non-financial aspects in Project appraisal. Apart from financial, commercial, strategic,

technical, organizational and human aspects, those studies highlight the importance of the analysis of social and environmental aspects. In a survey of Portuguese companies, Moutinho and Lopes (2010) find evidence that 62,5% of companies analyse environmental aspects and 40,6% consider social aspects in project appraisal. In this study, 55,2% and 33,3% of companies consider environmental and social aspects either important or very important in Project analysis.

The problem that recently occurred with the oil extraction by British Petroleum (BP) in the Gulf of Mexico makes us question whether all the aspects that could affect that project were taken into account when it was first considered. The crude oil spill from an oil well at sea has very serious social and environmental consequences. The Economist (2010a) mentions that the possible source of the problem may be related to the fact that management compensation and workers' personal advancement is more dependent on cost cuts than technical efficiency. This oil spill at sea has high costs for the project and an extremely negative impact on the company. The 63 miles of coastline affected, with impacts on fishing and tourism activities, mean clean-up costs and damages of \$ 20 billion and fines of up to \$ 17 billion for BP. Beyond the environmental problems, many local inhabitants have lost their jobs (The Economist, 2010d). To perform the clean-up operations, the company was forced to seek financing at higher rates, since its credit rating was downgraded. Due to this problem, the company has suffered a strong loss of reputation, will have to answer criminally to justice and may face retaliation in the form of refusal to grant further licenses to extract oil in that area (The Economist, 2010c). The first authors report that BP's market value has decreased substantially as a consequence of this problem, more than two to three times the costs of repairing the damage, due to the uncertainty of the operation taking place. The Economist (2010b) mentions that the final cost of the huge oil spill remains unquantifiable and The Economist (2010c) considers that many of the consequences will last for a long time: "When the waters finally clear, though, there could be some interesting sharks swimming in them".

Have the heads of BP analysed the environmental and social consequences that could come from this project? Have they ever thought about the social and environmental aspects of the project or have they just

taken into consideration the commercial and financial profits they could obtain in the short-term, making the most of the increase in crude oil price?

This work intends to present the information that should be analysed in an investment project in two areas, environmental and social, with important impact on the project's success.

This paper is organized as follows. In section two and three, we review the existing literature on social and environmental issues, respectively. In both sections we analyse which social and environmental characteristics to analyse, we identify main risks and we propose ways to mitigate them. We also consider which is the best moment to analyse these two types of factors. Finally, we present our conclusions.

SOCIAL ANALYSIS

Framework

The US Department of Commerce (1994) defines social impact as the group of consequences for human population of any private or public action that alters the way people live, work, entertain themselves, relate to each other, organize to meet their needs, and, generally, act as members of society. The term includes cultural impacts, involving alterations of the norms, values and beliefs that guide the knowledge acquisition process.

In order to analyse social context, it is necessary not only to know the range of impacts, but also to understand the social dynamics and the social differentiation processes prevailing in the project's area. The evaluation of impacts in human environments should be performed through direct, aesthetic, physical, historic, cultural, economic, social and health effects. On the other hand, it is also necessary to analyse the effects of conditions and factors that determine the state and conditions of the quality of life, employment, health, housing, monetary wealth and life style of those affected by the activities. It is also important to know the reaction to the implementation of the project and the social impacts and alterations in context, in a way to establish the appropriate procedures for its management (Barendse e Visser, 1995).

Smith (1995) presents as a basic principle the absence of suffering in the communities as a result of the company's activities. In this way, the project must be adapted to the values and objectives of the community. The companies should take on their social responsibility by integrating social impacts and concerns into project planning and implementation. For Schoeffel (1995) the project should be conducted based on the local sociological reality, so as to motivate the population to do what is intended to the company's benefit. It is necessary to deal with these issues not only in the short term, but also in the long run, protecting a positive relationship with the community.

McPhail e Davy (1998) suggest the integration of social concerns into the project through the analysis of private, governmental, local community and non-governmental organizations (NGO) factors.

Concerning private factors, the adoption of a social and environmental policy may supply the basis for the management of social aspects. The principles that should be reflected in this policy include: mutual respect, local partnerships, community involvement, long-term commitment, emphasis on sustainability, and acknowledgement of the legitimacy of the various stakeholders' perspectives.

On the one hand, it is necessary to identify the stakeholders and acknowledge the legitimacy of their perspectives. The groups of society that will be affected must, then, be identified and the social impact of the project in the population evaluated (Lopes and Flavell, 1998), so as to develop benefits that preserve the local identity and ensure a good relationship with the various stakeholders (Juslén, 1995). On the other hand, it is necessary to collect information on the initial situation of the aspects that will be affected in order to allow an analysis of the impact of the project on those aspects, when implementing it (Lopes and Flavell, 1998). It may also be important to verify the consequences of similar projects, if they exist, to determine the probable effects of the project on that community. Instead, it is possible to analyse the experience of other projects in similar communities, in order to predict how the project affects the community (US Department of Commerce, 1994).

Finally, there should be a concern for the integration of the evaluation of social and environmental impacts (relating to natural resources and human activity), for both may affect local communities deeply. Social and environmental effects are closely related (Taylor et al., 1995; Smith, 1995). Juslén (1995) identifies landscape and cultural heritage, as well as soil, water, air, climate and natural diversity as environmental aspects that have an impact on social evaluation.

The governmental factors presented by McPhail e Davy (1998) highlight the importance of local governments as defenders of the interests of the population and as entities that uphold the respect for social issues. On the one hand, the legal basis for the integration of social and environmental concerns into the project should be verified. Then, it is necessary to analyse the governmental demands, specified in legislation, related to political involvement in project planning. It is important also to clearly define the institutional responsibilities in managing the social and ecological aspects and the adequate development of the project's ability to deal with its "obligations" in terms of capability, expertise and financial resources. It may also be interesting to study the government's strategic plan for granting concessions and identifying social and environmental constraints. This way, the government may warn companies against investments in areas where social and environmental aspects may strongly constrain

the project's development. Of importance are also the institutional responsibilities between governments and the private sector for the support of social and community activities, namely in terms of housing, water and sanitation, education and training, healthcare, and infrastructures, such as roads and bridges.

The decision to invest should also consider the factors related to the civil society and NGO (McPhail and Davy, 1998). On the one hand, the possible development of partnerships of the civil society and NGO with governments and private entities should be analysed. On the other hand, it is also important to verify if the communities and the NGO recognize the legitimate role of governments in the decisions of strategic development in the best interests of the nation or region. Furthermore, it is important to analyse the attitude of the civil society and of the NGO in regard to the influence of companies in the government's social policies. Therefore, the limitations of companies to exercise social and political influence should be acknowledged, as well as their lack of authority to do it. It may also be relevant to analyse the structural development of the local community, verifying the legitimacy of the licenses of the NGO to work in the country, representing the population or groups of interest in the population. Finally, the company should understand the traditional role of NGO in the defense of social and/or environmental causes and their role as a partner in the development of long-term solutions.

The US Department of Commerce (1994) presents variable that may be influenced, positively or negatively, by the project, such as:

- Population characteristics: presents the population and the alterations that are expected to happen, ethnic and racial diversity, arrival and departure of temporary residents;
- Communities and institutional infrastructures: refers to the dimension, structure and organization level of local government. Also includes historical and present data on employment and industrial diversification, the size and level of activity of voluntary associations, religious organizations and groups of interest, and more importantly, how these institutions relate to one another;
- Social and political resources: refers to the distribution of authority and power, the identification of stakeholders and affected parties, as well as the leadership ability within the community or region;
- Individual and family alterations: factors that influence the daily life of individuals and families – includes attitudes, values, perceptions, family characteristics, work networks, friendship, risk perceptions, health and safety;
- Community resources: includes natural resources and use of land, availability of housing and community services such as healthcare, police, fire department, sanitation, historical, archaeological, and cultural resources.

The adequate management of these variables and social concerns is essential. In this analysis, there should be a balance between social, environmental, and economic considerations, allowing the combination of elements of social capital, environmental responsibility, and sustainable development.

Lopes and Flavell (1998) point out the most important social impacts: Job creation, health improvement and education programmes, building of housing, migration, expropriation, financial benefits, increase of monetary wealth of the population and construction of infrastructures to support the project; Evans (1987) adds the efficient use of resources; Juslén (1995) presents the level of pollution, psico-social impacts (e.g.: community cohesion), impact in state and private services, impact in mobility (transport, safety, obstacles) and self-esteem of participating citizens.

The social analysis should also be based on the evaluation of cultural factors. It is essential to know the cultural context to better understand differentiated management decisions. Cultural problems occur more frequently in international projects. The cultural factors involve the analysis of norms, values, beliefs, attitudes and traditions (Burdge, 2002), but also religious influence (Schoeffel, 1995), as well as the verification of the social conditions (ethnicity or race, family extent, predominantly rural population), economic conditions (per capita income, real wages, formal and stable sector employment, imported and exported goods, growth of work force, unemployment) and political conditions (age of the nation, political history, power of private and public institutions, legislation, strong or weak political system) – Muriithi e Crawford (2003). Boyacigiller (1990) points out the dominant religion, the business language, form of government, economic development and levels of emigration as necessary for the adequate analysis of the project. Shenkar (2001) shows evidence that companies prefer to invest in culturally similar countries. The greater the cultural distance, the lower the performance tends to be, the higher the cost of information and the lower the control of operations.

Social Risk Factors

Lopes and Flavell (1998) refer that the existence of social opposition to the project, the existence of public surveys with results that are adverse to the interest of the project, the lack of understanding of local culture may imply the end of the project, cause alterations in its specifications, as well as delays and increase in costs.

To Juslén (1995) the evaluation of social impacts is due to: possible environmental impact; intense public pressure; and demand from authorities. The objective would be to make sure that all significant impacts, positive or negative, are included in the analysis, since the identification of social risks may lead to the postponement or abandonment of the project, or its implementation as a pilot, with the possibility to

implement when those social issues are overcome (Lopes and Flavell, 1998).

Minimization of Social Risk

The company should develop knowledge and abilities to manage social aspects. McPhail and Davy (1998) suggest the prevention of negative environmental and social impacts through preventive correctional measures as preferable to the resolution of impacts afterwards, in a climate of litigation and public opposition.

The development of the project together with the community may lead to the reduction of negative impacts, which improves the public acceptability of the project. The understanding of the affected community's past behavior, as well as the profound knowledge of the country and people is fundamental for the project's compatibility with the population's habits (Lopes e Flavell, 1998; US Department of Commerce, 1994).

As a way to avoid the community's opposition to the project, the companies show an interest in ensuring socially responsible behaviours (McPhail and Davy, 1998). A good public image of the project should be built for, in analyzing the conditions the project offers to the society, the most important thing is the sense of perception, from the community, of the advantages the project offers (Lopes and Flavell, 1998). However, it is essential to verify if the result of the project compensate the spending necessary to make it socially acceptable.

The stakeholders, as an important source of information, have a fundamental role in identifying social and environmental concerns, as well as in developing management strategies to increase the project's benefits while minimizing negative impacts (McPhail and Davy, 1998). The involvement of stakeholders may be done through information exchange, consultation, participation and joint decision-making. Public participation may allow the clarification of areas where there are conflicts and lead to the resolution of those conflicts (Rivers and Buchan, 1995).

The members of the community should be given the opportunity for a timely presentation of their proposals and perspectives, creating a dynamic and opinion interchange. The creation of population liaison committees – as a channel of information and discussion – is a viable solution in this dynamic to avoid suspicions, create motivation or ensure mutual cooperation (Lopes and Flavell, 1998). This way, the opinion of the stakeholders in the community works as an information input to the project (McPhail and Davy, 1998; Lopes and Flavell, 1998).

When implementing a project that goes against the community's interest, it is necessary to develop preferential benefits to the affected communities, in order to capture their interest in the project. The local population should be granted priority access to these benefits and the placement of the project should be such that it maximizes these benefits. The projects may imply

the construction of housing and other infrastructures such as roads, schools, hospitals, as well as job creation for the local population (Lopes and Flavell, 1998). When immigration is essential for a project, it is important to account for the interests of local populations (McPhail and Davy, 1998). On the other hand, a company should attribute fair compensation to the population for damages caused, present and future, based on local values and community traditions (Lopes and Flavell, 1998). The main stakeholders should be granted (directly and indirectly, in a fair and equitable manner) the distribution of income from the project. While for Lopes and Flavell (1998) the injection of money into the community constitutes an alternative, McPhail and Davy (1998) refer that compensations should not be monetary, but based on the improvement of the community's conditions so that all the members may benefit. The bigger the problems caused, the larger the compensation should be.

It is also necessary to investigate the possibility of directing a portion of the government's reward towards the development of local initiatives and to stimulate private investments in the community (McPhail and Davy, 1998). The project's promoter should complement the government's responsibilities, increasing the existing social choice. Smith (1995) adds that the companies should contribute to the resolution of matters with social impact, even if they are outside the scope of the project. The support of local activities allows the expansion of the good relationship with the local community throughout the lifespan of the project (Lopes and Flavell, 1998).

The advantages of these partnerships with the community, essential if the companies want to maintain the informal license to work, are related to the mobilization of resources (financial, skills, among others), the improvement in the understanding of potential adversities and the transfer of knowledge and technologies (McPhail and Davy, 1998). Other partnerships may arise with local governments, NGO or financial international institutions in the preparation of social programmes to support sustainable development or promote sócio-economic development. On the other hand, Chase (2002) and Pradhan and Rawlings (2002) refer that it may be advantageous to implement the project, especially those with high social needs, in regions supported by the World Bank, since this institution would replace the company in taking social responsibilities.

To McPhail and Davy (1998) there should be a concern in dealing with effective conflict situations - the reduction of potential conflicts with the community can bring opportunities: easier access to future exploration concessions; lower costs resulting from (less) delays in the decision-making; improvement of the workers' quality of life. The companies and communities must develop ways to resolve differences without involving third parties, based on mutual trust and understanding.

However, when a solution is not possible, intermediaries should be used that are impartial, respectable, independent and accepted by all parties involved.

To deal with social aspects, it is essential to maintain constant interaction between social teams and all others. Managers, on the other hand, must be trained and prepared to be watchful of social aspects and to deal with social problems (Lopes and Flavell, 1998). In developing a social and environmental policy, it is important to use qualified personnel, create understanding of these issues among technical, environmental and social specialists, as well as knowing and understanding the value of social and human capital (McPhail and Davy, 1998). Therefore, a project must be implemented with respect for economic and financial criteria, without exceeding the maximum acceptable level of damage determined by the cost-benefit ratio and by the social standards (Knudsen and Scandizzo, 2005). The projects should be culturally accepted, otherwise they become impracticable. The managers should be trained about local culture and try to adapt the project without injuring susceptibilities or the social values of the local population. Sometimes, this means changing or eliminating aspects of the project that are considered unacceptable by the community (Lopes and Flavell, 1998). In this way, the project becomes compatible with the values and traditions of local society.

Note that the bigger the project, the higher the probability that its social impact is also high. For each step of the project, the potential impacts in each social variable identified must be evaluated and the problems should be analysed through their constituent parts.

Evaluation of Social Aspects

Lopes and Flavell (1998) indicate that the evaluation of these factors should be concentrated in the early stages of the project. For Taylor et al. (1995) the description of the social impacts should be made since the beginning to allow the team to identify the critical points. However, apart from the information collected in the beginning, it is important that new information can be obtained at any time. A proactive attitude should be adopted in the study of negative social effects, before they occur, so that recommendations can be given to avoid them. Therefore, the evaluation of social impacts must be performed continually throughout the project, in different ways for each step (Juslén, 1995).

The social analysis should be performed, according to Lopes and Flavell (1998), together with the project's technical analysis so that it can be an input to the technical analysis. McPhail and Davy (1998) highlight the importance of evaluating this component together with the environmental analysis, due to possible (negative) impacts that these issues may have on local communities. Lopes and Flavell (1998) consider that, in order to increase the credibility of the analysis, the social evaluation must be made not only by internal

specialists, but also by external, independent specialists. It is fundamental that the project manager also be involved in the analysis. A good relationship with the exterior social liaison group must also be sought out so that all the problems that are identified may be solved.

ENVIRONMENTAL ANALYSIS

Framework

Senécal et al. (1999) define the environmental impact analysis as the process of identifying, predicting, evaluating and minimizing the biophysical, social and other effects of the development proposals. They, therefore, present as the main goals: ensuring that environmental considerations are explicitly incorporated into the decision-making process; forecasting and avoiding, minimizing or compensating negative effects; protecting the productivity and capability of natural systems and ecological processes; promoting sustainable development; and optimizing the use of resources and opportunity management. To these, McGrath and Bond (1997) add the knowledge of the environmental benefits and costs of the project.

The environmental evaluation should contain the impacts on the environmental and ecologic contexts, as well as the impacts on the social, cultural, economic, political contexts, as well as in terms of health and life style, among others (Lawrence, 1997; Senécal et al., 1999). The environmental impacts may affect the quality of air, water, soil, fauna and flora, geology, ecosystem, landscape, historical monuments, tradition and health (Thérivel, 1997). Lopes and Flavell (1998) add safety as a factor to be considered in this analysis.

The projects should be viewed as a way to preserve, or at least not harm, the environment (Lopes and Flavell, 1998). Damania (2001) defends that investing in damage control may be lucrative, in that it may more than compensate in terms of cost savings in the future.

The environmental damage is closely related with social issues in the sense that the greater they are, the lower the well-being of the community tends to be, given that these damages affect the quality of the human environment (Dijkstra, 2003; US Department of Commerce, 1994). The environmental factors should be adequately incorporated into the investment decisions so that they are socially accepted, ensuring the companies' social responsibilities as their ultimate goal (Jiliberto, 2002; Tribe, 1996). All socially unacceptable potential environmental impacts are to be avoided.

According to Lopes and Flavell (1998) the analysis of environmental aspects is often determined by the need to respect the regulations on those environmental effects. To Tribe (1996), as well, the control and monitorization of environmental issues is, usually, the direct result of legislation. In fact, it is necessary to analyse the goal of state environmental policy in terms of: discouraging activities with undesirable green effects; encouraging the

modification of industrial activity with desirable green effects. The state intervention may happen through: grants, taxes, licenses and control mechanisms. For Leu et al. (1996) the fundamental components of an effective environmental impact evaluation system should incorporate the following aspects: environmental policy, regulations and technical guidelines, environmental administrative support, clearly defined environmental impact evaluation procedures, state of the reports of environmental impact evaluation, monitoring and incentive to upholding the environmental impact valuation, effective practical implementation of the environmental impact evaluation, resource availability (human and physical) to implement the environmental impact evaluation, implementation of strategic environmental impact evaluation and international interactions. When performing the environmental analysis, companies should consider the interests of the main stakeholders in the project and adopt green behaviours that do not harm the project (Buysse and Verbeke, 2003; Weston et al., 1997). On the other hand, it may also be relevant to define the environmental area of influence of the project, especially in case there are environmental impacts in a country (region) different than that where it is implemented (Mansouri and Youssef, 2000). Note that the attention dispensed to environmental aspects may vary from project to project, depending on the industry, duration (McGrath and Bond, 1997) and size (Tribe, 1996).

Environmental Risk Factors

Given the importance of preserving the environment, incurring in environmental damages may cause public discontent and social opposition to the project. Not following environmental legislation, if it exists, and the existence of public environmental surveys with results negative to the project may assume great relevance, if they cause delays and increased costs for the project. Not fulfilling environmental requirements may cause loss of image and reputation for the project. On the other hand, the existence of environmental legislation may influence the decision to implement the project (Lopes and Flavell, 1998; Nardini, 1997). Tribe (1996) points to three groups of sources of environmental impact. The first refers to the impact on production due to the demand for input materials (renewable or non renewable), namely: the needs of energy, the level of pollution originated by the production and the use of local natural resources. The second refers to the impact on the use of product characteristics, such as: the pollution with the use of the product; the energy used; the production of waste materials; noise; and other types of pollution. The third refers to the impact at the end of the use of the product, verifying if the materials are recyclable.

Minimizing Environmental Risks

The objective of this analysis includes the minimization of the negative environmental impacts (Lopes and Flavell, 1998; Zaring, 1996), which necessarily means not ignoring them, even when legislation imposes nothing, adopting an open and consultative attitude and elaborating environmental impact studies.

As a way to improve the alignment of the company and its strategy with the growth of environmental concerns, and expectations of the stakeholders, the companies should voluntarily establish minimum standards for environmental requirements when there is no legislation, deepen the demands of environmental regulations, and lastly not lower the environmental demands to levels below minimum standards aiming at lowering costs (Buysse and Verbeke, 2003; Lopes and Flavell, 1998).

The pursuit of the goals of the project often means the existence of an adequate trade-off between environmental, financial and technical aspects. There should, thus, be a balance between the best possible technology, its cost, and the perceived environmental level (Lopes and Flavell, 1998). According to Damania (2001) and Gray and Shadbegian (1997) the environmental issue in companies often depends on the technology adopted – the better and more recent the technology, the less damages tend to be caused to the environment. The adoption of new techniques and a more efficient technology in environmental terms is influenced by environmental regulation, in that the increase in environmental restrictions leads to the increase in investments in “clean” technologies (Farzin and Kort, 2000; Gray and Shadbegian, 1997).

The adoption of a consultative perspective includes the participation of the public, as a way of not excluding those that may be affected. Therefore, social analysis techniques are used to mitigate the opposition based on environmental factors, such as: informing and listening to all those affected and interested through the creation of community liaison committees, compensation for damages caused, avoiding suspicions through the use of independent experts and making use of the knowledge of the local population (Lopes and Flavell, 1998).

It is important to try to satisfy the environmental expectations of all the stakeholders, although not all are equally important for the companies. Lopes and Flavell (1998) identify the local community and the NGO, such as Greenpeace and Friends of the Earth, as important groups of environmental pressure that can push companies to improve their environmental performance. Buysse and Verbeke (2003) add as main environmental stakeholders the clients and shareholders. In fact, many companies implement environmental activities due to the pressure from stakeholders (Gilley et al., 2000).

The most adequate process of environmental management must be based on flexibility and continuity, so as to allow an immediate response to any unforeseen impact. A proactive project management also allows

companies to avoid the occurrence of potential negative environmental impacts and maximizes the global environmental performance (Morrison-Saunders, 1996). Aiming at minimizing the negative environmental impacts Hart (1995, *cit. in* Buysse and Verbeke, 2003) developed a corporate environmental strategy based on five pillars: investment in the product and in the manufacturing process as a way to obtain green skills; investment in employees environmental knowledge; investment in organizational skills, measured by the involvement of functional áreas in environmental management; environmental management based on a written environmental plan and the elaboration of internal and external environmental reports; integration of environmental issues and participation of green managers in the strategic planning. Tribe (1996) adds the use of recycled material.

Within environmental analysis, it is also important to gather base data for the future comparison and monitoring, and it is often necessary to do some experimental work (Lopes and Flavell, 1998).

The environmental aspects should take relevance in the decision-making process, knowing that the risks will be minimal if the projects do not deviate from the Basic Principles established by the International Association for Impact Assessment: “**Purposive** - the process should inform decision making and result in appropriate levels of environmental protection and community well-being; **Rigorous** - the process should apply “best practicable” science, employing methodologies and techniques appropriate to address the problems being investigated; **Practical** - the process should result in information and outputs which assist with problem solving and are acceptable to and able to be implemented by proponents; **Relevant** - the process should provide sufficient, reliable and usable information for development planning and decision making; **Cost-effective** - the process should achieve the objectives of EIA within the limits of available information, time, resources and methodology; **Efficient** - the process should impose the minimum cost burdens in terms of time and finance on proponents and participants consistent with meeting accepted requirements and objectives of EIA; **Focused** - the process should concentrate on significant environmental effects and key issues; i.e., the matters that need to be taken into account in making decisions; **Adaptive** - the process should be adjusted to the realities, issues and circumstances of the proposals under review without compromising the integrity of the process, and be iterative, incorporating lessons learned throughout the proposal's life cycle; **Participative** - the process should provide appropriate opportunities to inform and involve the interested and affected publics, and their inputs and concerns should be addressed explicitly in the documentation and decision making; **Interdisciplinary** - the process should ensure that the appropriate techniques and experts in the relevant bio-physical and socio-economic disciplines are

employed, including use of traditional knowledge as relevant; **Credible** - the process should be carried out with professionalism, rigor, fairness, objectivity, impartiality and balance, and be subject to independent checks and verification; **Integrated** - the process should address the interrelationships of social, economic and biophysical aspects; **Transparent** - the process should have clear, easily understood requirements for EIA content; ensure public access to information; identify the factors that are to be taken into account in decision making; and acknowledge limitations and difficulties; **Systematic** - the process should result in full consideration of all relevant information on the affected environment, of proposed alternatives and their impacts, and of the measures necessary to monitor and investigate residual effects” (Senécal et al., 1999).

Environmental Impact Assessment

The analysis of environmental aspects should begin in the initial stages of the project's life cycle, so as to influence the development of the project in the following stages (Lopes and Flavell, 1998; Senécal et al., 1999; Tribe, 1996). Note that the environmental aspects should be reviewed through time. The assessment should be phased with the development of the project, so that the conclusions of a certain stage are taken into account in the definition of the work for the following stage (Lopes and Flavell, 1998).

The analysis of the environmental aspects should be carried out in coordination with the technical analysis of the project, so as to become an input to the technical alternatives (Lopes and Flavell, 1998; Zaring, 1996). To perform this assessment, an environmental coordinator should be designated in the initial stages that relates the environmental impact studies to the project manager, so that he can coordinate with all the other areas (Lopes and Flavell, 1998). To Buysse and Verbeke (2003) and Zaring (1996) a manager should also be in charge of the responsibilities for environmental management.

McGrath and Bond (1997) refer that the environmental assessment should be performed by experienced consultants. In fact, also Lopes and Flavell (1998) and Weston et al. (1997) indicate that, apart from the internal experts, it may be necessary to recruit local and international external experts with specific knowledge of the place or region. They may supply an independent opinion with the objective of better understanding the specific problems and needs of the area, without neglecting the existence of other functional areas.

CONCLUSIONS AND FURTHER RESEARCH

Given the limitations of the financial analysis in project appraisal - resulting of not incorporating qualitative, intangible and subjective aspects - it is to be expected that other factors, of non-financial nature, may affect the implementation and viability of investment projects.

As in the scope and objectives of International Conference on Project Economic Evaluation 2011 the “economic perspective of the project underlines the need to properly consider and include in the analysis the social and environmental dimensions of the projects”. WBCSD (2005, p.5-6) refers that the assessment of impacts on social and environmental systems “requires a range of different approaches, methods and techniques. Direct impacts are relatively straightforward to identify, but the assessment of indirect and cumulative impacts is more complex and the determination of magnitude (size and extent of the impact) and significance (the importance for decision making) is difficult. Social impacts are often the most difficult to predict, due to the lack of a clear cause-effect relationship when working with human responses to change, meaningful baselines, etc. A good environmental social impact assessment process helps a company identify the critical social and environmental issues associated with a project, and ensure that positive impacts are optimized and negative impacts are minimized and mitigated. An effective environmental social impact assessment process can improve local community understanding of the whole project, increasing trust between the company and the local community, as well as increasing the sustainability of the project.

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ECONOMIC EVALUATION OF A DEMAND RESPONSIVE TRANSPORT IN RURAL AREA

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Economic evaluation, Sustainability, Transport systems evaluation

ABSTRACT

The provision of traditional public transport services in rural areas have shown to be very inefficient and ineffective. In fact, rural areas are typically characterized by low levels population density leading to complex demand patterns (demand is low and spread over a large area) which leads to low levels of service of conventional transport services (low frequency, old vehicles, etc). Demand Responsive Transport projects have been seen as an interesting alternative solution already adopted in several countries. There are however some issues concerning demand responsive transport (DRT) costs and benefits that still have to be addressed. In this research work a global analysis about internal and external costs is proposed aiming to support decision makers investigating the impacts and measures related to the adoption of a flexible transportation system solution.

INTRODUCTION

Over the years, transport has been playing an increasing role in the world economy, as world trade depends on the movement of people and goods. However, the systematic economic analysis of transports system is still a complex issue since it faces a number of specific characteristics associated not only to the nature of its demand and supply as well as to all its externalities. Transport problems are complex and difficult to handle, and intelligent decisions must be oriented towards maximizing the advantages of the new transport provision while minimizing their costs and undesirable side-effects. Since resources are always scarce, a major effort in adopting efficient investment decisions is required. Traditionally public transport systems in rural areas have been based on static services: fixed routes, fixed stops and fixed schedules. The low levels of density observed in some of these areas leads to fragile supply systems with high levels of inefficiency and

efficacy as a result of under-investments strategies over the years.

In fact, low rates of occupation of vehicles and high rates of population dissatisfaction are frequently observed (e.g. Quadrifoglio and Li, 2009). Rural area inhabitants are seeing their mobility limited, using frequently, the good-willing of neighbors or any family member to make their trips. Therefore, functional social exclusion increases in those rural areas.

To overcome some of these problems, flexible transportation systems have been adopted over the last decades, as reported in some studies (e.g. Brake et al., 2004; Mulley and Nelson, 2009). In fact, there are many successful cases all over the world of the flexible transport system called Demand Responsive Transport (DRT). Most of the cases reported refer to rural areas, small towns and to serve special populations (elderly and people with disabilities) in large cities.

DRT is an attractive solution, because offers a user-friendly answer to passengers needs and overcomes some shortcomings of traditional transport services.

Implementations of DRT systems in literature (e.g. Brake and Nelson, 2007; Mulley and Nelson, 2009; Nelson et al., 2010), obeys to several conditions, encompassing high dynamic levels of both planning and coordination processes. The use of modern information and communication technologies, such as Intelligent Transport Systems (ITS), allied to adequate strategy planning services has been pointed out as the solution to improve the costs-effective performance of DRT services.

As Brake *et al.* (2004) argued the main architectural component of a telematics-based DRT system is a control centre (usually named as Travel Dispatch Centre (TDC)) using ITS which has the capacity to process demand requests and dynamically assign passengers to vehicles and optimize routes.

The aim of this paper is to develop a framework to carry out an economic evaluation of such a transportation system, setting up the most important evaluation criteria and quantification (all internal and external costs and all benefits).

It aims to develop and prepare a methodology for the evaluation of a DRT system in rural areas.

This paper is structured as follows: in the next section cost structure of transportation systems is reviewed and analyzed and the approach adopted is presented. Then, DRT systems are examined and their specificities discussed. Finally performance indicators are proposed and, in the last section, some conclusions are drawn.

COST STRUCTURE IN TRANSPORT PROJECTS

There has been a growing number of research studies (all over the Europe and U.S.), focused on the evaluation of real costs and benefits of transport systems (Jakob et al., 2006).

Most authors involved in transportation studies sustain that transportation choices are expensive and complex and have long-lasting consequences and therefore, it is crucial to analyze a large number of design alternatives to increase the probability of

defining a good design for the service (Nickel et al., 2009). A comprehensive evaluation methodology is required.

According with some authors (e.g. Litman, 2009), the term “cost” involves tradeoffs between uses of resources (which can involve money, time, or loss of an opportunity to have a benefit) and can be seen as a reduction in terms of benefits (also, a benefit, can be defined as a reduced cost). This approach allows quantifying impacts, enabling a comparative analysis of alternative scenarios in terms of, for instance, reduction of travel time, reduction of air pollution, noise, accidents, etc.

For the sustainability of transport investment decisions it is important to consider their social costs. These costs can be classified either as internal costs or external costs (from the operator point of view), as described in Figure 1, and detailed in the following subsections.

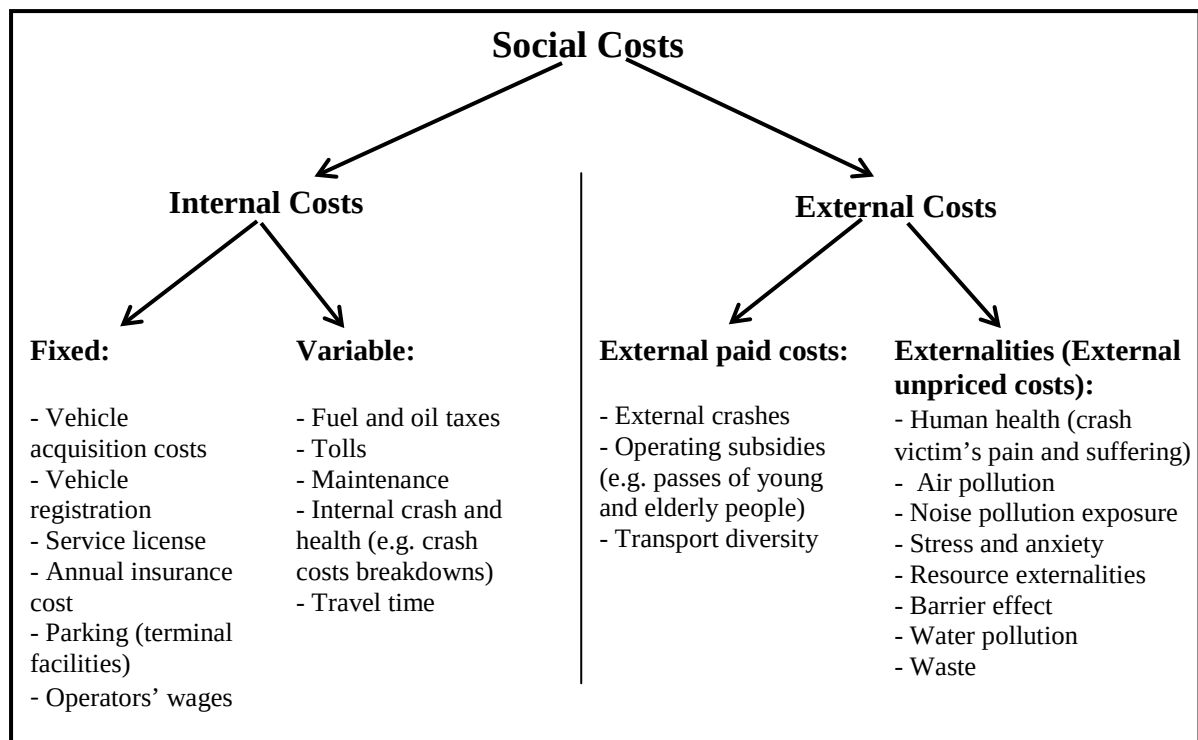


Figure 1. General social costs associated with a transport service (operator's point of view).

Internal Costs

Internal costs are supported by the transport service operator and can be classified into fixed and variable costs.

Fixed costs, are easily measurable and common to all transport investment projects. Among several expenditures, they can include (AA, 2002; Jakob, 2006; Litman, 2009):

- Vehicle acquisition and ownership costs;
- Vehicle registration;
- Service license;
- Annual insurance cost;
- Internal parking (both terminal and maintenance facilities which can involve costs such as: lighting, repairs, security, landscaping, snow removal, access control (e.g., entrance gates), fee

collection (for priced parking), enforcement, insurance, labor and administration)

Additionally, drivers and operators' wages are, in general, internal fixed costs in the transportation sector.

Variable costs, depend on the level of operation and include (AA, 2002; Litman, 2009):

- Fuel and oil taxes (highly dependent on the price of crude and on the level and the type of operation undertaken (kilometers));
- Tolls (vehicles which circulate in highways);
- Maintenance (costs with vehicle repairs and conservation, a function of vehicles usage);
- Internal crash and health (crash costs caused by vehicle breakdowns or accidents and include internal costs associated with repairs and damages to those travelling and costs imposed to other people (e.g. property damages to vehicles, police and legal costs, medical treatment costs, rehabilitation etc (Jakob *et al.*, 2006; Santos *et al.*, 2010));
- Travel time (refers to the costs or benefits from reduced travel time).

Private transport has a similar cost structure as public transport, but it does not include any tax benefits in some attributes such as mandatory annual inspection, road user tax, levies on fuel, motor vehicle registration fees, annual insurance cost and relicensing (Jakob *et al.*, 2006).

External costs

External costs in transport systems are inevitable and are the result of a set of their impacts produced in the society. Santos *et al.* (2010) stated that, the most important negative impacts of road transport are: accidents, road damage, environmental damage, congestion and oil dependence and correspond to a market failure, as incapacity of reaching an efficient equilibrium. For Jakob *et al.* (2006), there are three main external costs evaluated in the literature: external accidents, air pollution and climate change. Litman (2009) considers further external costs: external parking; road facilities; transport diversity; land value; traffic services; noise; resource

externalities; barrier effect; land use impacts; water pollution and waste. These authors don't distinguish externalities from external costs.

Recently, there have been some references to externalities benefits, such as, improved mobility and access to resources and goods mitigating social exclusion. However, some authors considered that these benefits are not external because who benefits from transports are those that use them (Jakob *et al.*, 2006; Litman, 2009; Santos *et al.*, 2010). The consumption of resources to allow these benefits has, at the same time, wasted natural resources, such as fossil fuels, devastated forests, ruined soils, deteriorate the quality of air, destroyed biological diversity and produced greenhouse gases.

In this research study, it has been assumed that external costs and externalities are different concepts with frontiers not easy to define:

➤ External costs defined as measurable costs that affect the financial viability of the project. These costs are caused by external factors and contain external crashes (accidents caused by others), operating subsidies and transport diversity (the quantity and quality of transport services available in a particular situation (Litman, 2007).

➤ Externalities defined as unpriced costs and benefits caused by an activity (or agent) and have impact on another. For example, in the transportation sector, externalities include environmental and social impacts which are not borne by the producer or consumers of the service.

Externalities are difficult to measure since they are caused by the unwanted effects of the transportation system (e.g. air and noise pollution and congestion) and damage human health and the environment:

- o Human health: crash victim's pain and suffering, air and noise pollution exposure, stress and anxiety, delays, etc, (Jakob *et al.*, 2006). (see Table 1).

Pollutant	Quantified Health Effects	Unquantified Health Effects	Other Possible Effects
Ozone	Mortality Minor RADs* Respiratory RADs Hospital admissions Asthma attacks Changes in pulmonary function Chronic sinusitis and hay fever	Increased airway responsiveness to stimuli Centrocinar fibrosis Inflammation in the lung	Immunologic changes Chronic respiratory diseases Extrapulmonary effects (changes in the structure or function of the organs)
Particulate matter / TSP/ Sulfates	Mortality Chronic and acute bronchitis Hospital admissions Lower respiratory illness Upper respiratory illness Chest illness Respiratory symptoms Minor RADs Days of work loss Moderate or worse asthma status	Changes in pulmonary function	Chronic respiratory diseases other than chronic bronchitis Inflammation of the lung
Carbon monoxide	Mortality Hospital admissions- congestive heart failure Decreased time to onset of angina	Behavioral effects Other hospital admissions	Other cardiovascular effects Developmental effects
Nitrogen oxides	Respiratory illness	Increased airway responsiveness	Decreased pulmonary function Inflammation of the lung Immunological changes
Sulfur dioxide	Morbidity in exercising asthmatics Changes in pulmonary function Respiratory symptoms		Respiratory symptoms in non-asthmatics Hospital admissions
Lead	Mortality Hypertension Nonfatal coronary heart disease Nonfatal strokes Intelligence quotient (IQ) loss	Neurobehavioral function Other cardiovascular diseases Reproductive effects Fetal effects from maternal exposure Delinquent and antisocial behavior in children	

Table 1- Gases emissions sources and scale which pollutes the air and their impacts, that causes people health problems (adapted from Litman, 2009).

o **Resource externalities:** Economic costs from importing resources; Security risks (maintaining access to resources); Environmental damages (damages from resource extraction, processing and transport, including oil spills e.g. vegetation (Jakob *et al.*, 2006)); Depletion of non-renewable resources (depriving future generations of resources, such as petroleum (Santos *et al.*, 2010)).

o **Barrier effect:** refers to delays, discomfort and lack of access that vehicle traffic imposes on other transport modes and it is equivalent to traffic congestion costs. In rural areas there are additional barrier effects, such as the need to use private transport to deal with the lack of adaptability between public transport and mobility needs of the residents.

o **Water pollution:** when water is negatively affected due to the addition of large amounts of materials, such as car oils. These problems are related to vehicle maintenance and usage.

o **Waste:** includes damage costs associated with the unsuitable dumping of wastes as used tires, batteries, oil and other harmful materials resulting from motor vehicle production and maintenance. These wastes impose economic, human health and environmental costs (Litman, 2009).

Evaluation

Many authors, including the European Union, considered crucial to evaluate a transport project by internalizing externalities of transport (Santos *et al.*, 2010; EUL, 2011). However this is quite difficult to accomplish since, in general, they cannot easily be quantified. (e.g. Jakob *et al.*, 2006; Litman, 2009; EUP, 2011).

There are several techniques in the literature to quantify and monetize external effects of vehicles

such as: damage cost method or control and prevention cost method (Litman, 2009). Alternatively, some authors advocate the implementation of eco-taxes, subsidies for using cleaner technologies, thus avoiding socio-environmental costs, or using evaluation methods such as cost benefit analysis or life-cycle analysis (ExternE, 2005).

The more common economic instrument to internalize external costs such as CO₂ emissions is through the implementation of taxes and tolls. While some externalities, such as congestion, have a localized impact (place and time), and justifies a restricted measure (toll), others have global impact (e.g. climate change), so the approach should be more general, like a fuel tax (EUL, 2011).

The European Commission states that external costs should be treated as “social marginal cost charging”, which should be the additional short-term cost generated by one extra person using the transportation system. Charging the additional costs imposed to the society will help to ensure fair treatment for users or non-users, basis on “polluter pays” principle. Furthermore, the Commission considered the increase of the use of technology would enable to internalization.

Several authors defend that cost-benefit analysis (CBA) is one of the most widely applied methods for project appraisal for large-scale investments in the terrestrial transport sector (e.g. Stevens, 2004; Jakob *et al.*, 2006; Thomopoulos *et al.*, 2009; Nickel *et al.*, 2009).

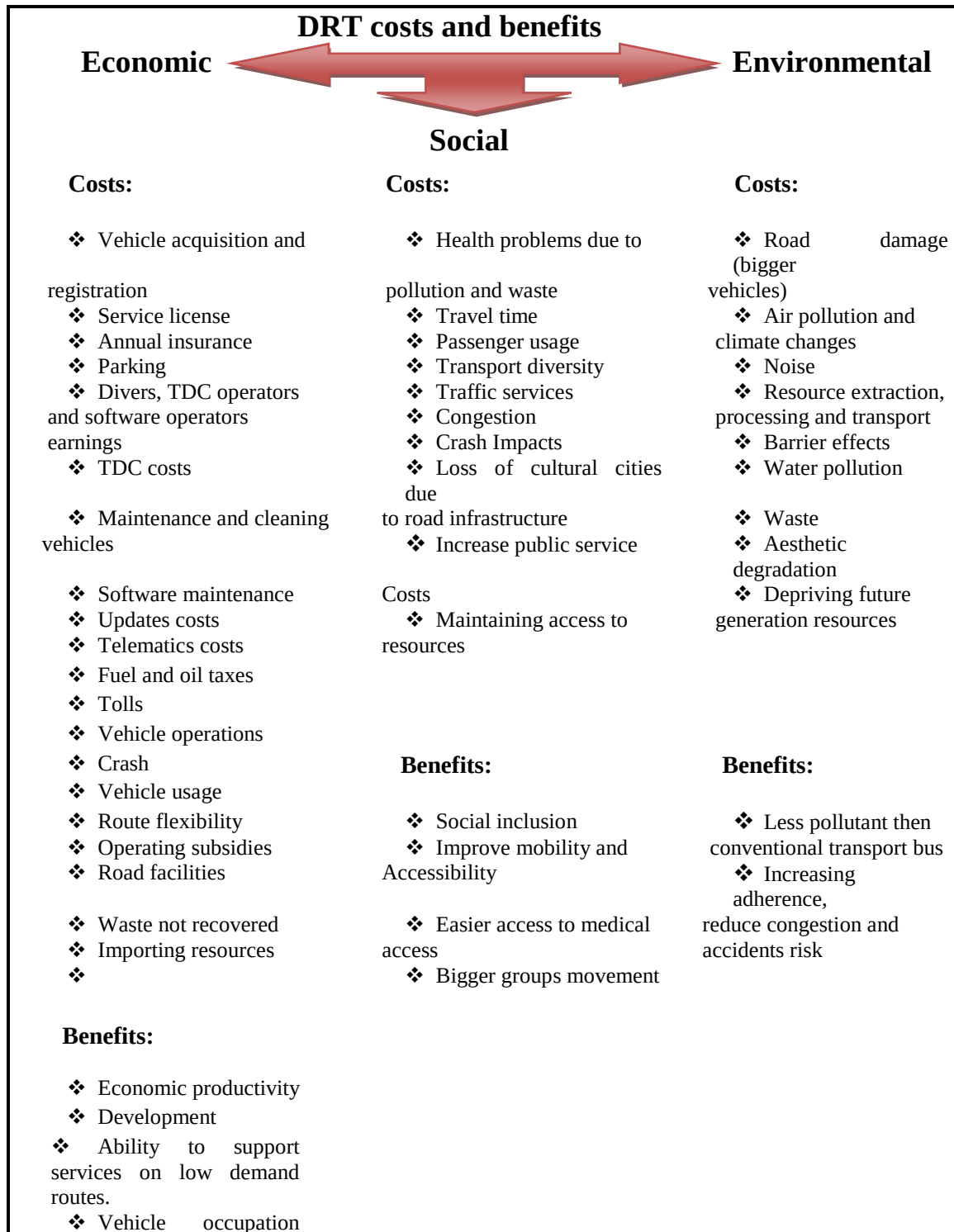
On the other hand, an investment project can be evaluated taking into account both social and economic impacts on the local community through social return on investment (SROI) analysis. The SROI approach captures the economic value of social

benefits by translating social objectives into financial measures of benefits and such analysis help communicating the information with stakeholders holding different objectives and preferences (Wright *et al.*, 2009). The SROI analysis methodology was created from the traditional cost-benefit analysis method in the late 1990's (Emerson, 2000). Other methods, such as the social cost benefit analysis (SCBA) have been broadly applied in many

countries, but less commonly in mainstream transport analysis (Haezendonck, 2007).

COST STRUCTURE IN DRT PROJECTS

A DRT system, as a transport service, will have an identical cost structure with internal (fixed and variable) and external costs. However there are some specificities that should be considered when developing an evaluation framework (see figure 2).



rate.

Figure 2: DRT impacts on costs and benefits (adapted from Litman, 2009).

Further to the internal costs of a traditional transport system, a flexible transportation system has different characteristics and extra operational cost, as depicted in Table 2, concerning some of its operational issues. As referred before, the success of a DRT systems involves the use of ITS and, eventually, a TDC, implying additional costs related to its acquisition (e.g. facilities, hardware and software), maintenance and operation (Mageean and Nelson, 2003).

TDC costs are highly dependent on the level of complexity and cleverness of the system, namely degree of flexibility (time window restrictions of pre-booking; dynamic routing and scheduling) and other functionalities, such as Interactive Voice Response System (IVRS) or Internet booking.

Additionally, operating a flexible transportation system might add extra operational costs whenever high route/schedule flexibility is adopted as a result of longer distances travelled.

On the other hand, savings can be achieved by using smaller vehicles (with lower operational costs) and increasing its occupation rate. A relevant aspect

about DRT systems is that they typically use smaller vehicles than the conventional transport, so they tend to produce less pollutant emissions. Additionally, they usually use newer vehicles that have more effective emission control systems (note that most conventional transport operators operating in low-density rural areas make use of their older vehicles). Furthermore, and one of the most important impacts (positive externalities) of flexible transportation systems, are the social benefits - it is expected that demand for public transport will raise eliminating some of the drawbacks of traditional systems, improving people's mobility and accessibility. Social exclusion, isolation and solitude of special populations (elderly, people with disabilities, inhabitants of remote rural areas) can be significantly reduced.

Other economic benefits referred in the literature are economy growth (promoting new jobs), people willingness to pay for a more reliable and flexible transport and environmental benefits (e.g. reducing individual vehicle circulation and reducing accident risk).

Table 2: Characteristics of DRT systems (adapted from Mageean and Nelson, 2004).

Indicator	Positive outcomes	Negative outcomes	Variable outcomes
Operating costs	Cost savings are made: relative not direct	Direct comparison between sites is difficult Costs are not covered by fare revenue	High compared to regular services Vary between sites Lower in areas of high population density DRT is less likely in deregulated open access markets
TDC cost	Simplification of procedures reduces costs IVRS and Internet booking will help reduce costs Economies of scale possible		Level of patronage is critical Wide variations even in similar market environments STS costs are regarded as a social necessity
Vehicle usage	High load factors on virtual flexible routes Increased since DRT introduced		
Route directness	Small increase in distance travelled		
Passenger usage	Increased since DRT introduced		

Mageean and Nelson (2003) concluded that the use of telematics enhances DRT services, improves cost-effectiveness by reducing expenditure or improving fleet operations; also, it improves social conditions by increasing service levels and access to facilities. However, as stressed by the same authors, the viability of DRT services as a self-supporting system has not yet been demonstrated. The complexity of the viability analysis derives from several issues such as fare levels definition, subsidies and total (buses and TDC) operating costs. Nevertheless, they should be regarded as a vital supplier of services where conventional solutions are unsustainable, e.g. low demand areas and special transport services (Wright *et al.*, 2009).

Others specificities of DRT systems must be taken into account: characteristics of the local population, transport network, the patterns of commuters, and the framework within which the system works, determine the demand and operational scale of system and, as such, can affect performance and efficiency.

Telematics based DRT services, by incorporating individual customer preferences, put forward the opportunity of bigger reliability and punctuality than in conventional public transport services.

DRT services using telematics will promote efficiency and effectiveness and will assist the action plan of the internalization of the externalities costs.

PERFORMANCE EVALUATION

One of the most important aspects in an investment project is the performance evaluation through the use of

indicators or measures. With a performance measure it is possible to monitor the progress of the system towards all goals (Sousa *et al.*, 2005). In a transport system, the use of a set of performance measures aims at providing the organization with the ability to assess the outcome of possible changes implemented by measuring and analyzing a set of engineering and operational attributes (NCHRP, 2006).

Social, environmental and economic impacts are increasingly important aspects for decisions in transport investments. According to NCHRP (2006), there are a set of performance measures that are essential to assess and control a transportation system (see Figure 3):

- Economic development: measure direct and indirect impacts of transport on the development of economy and includes preservation of assets, operation and maintenance and service level;
- Environmental impacts: measures effects on environment.
- Social impacts: measures effects on wider society or on population groups, namely: mobility and accessibility, safety and security.

The adoption of good performance measures is required in any investment project before its implementation, to recognize productive strategies and abandon the unproductive ones.

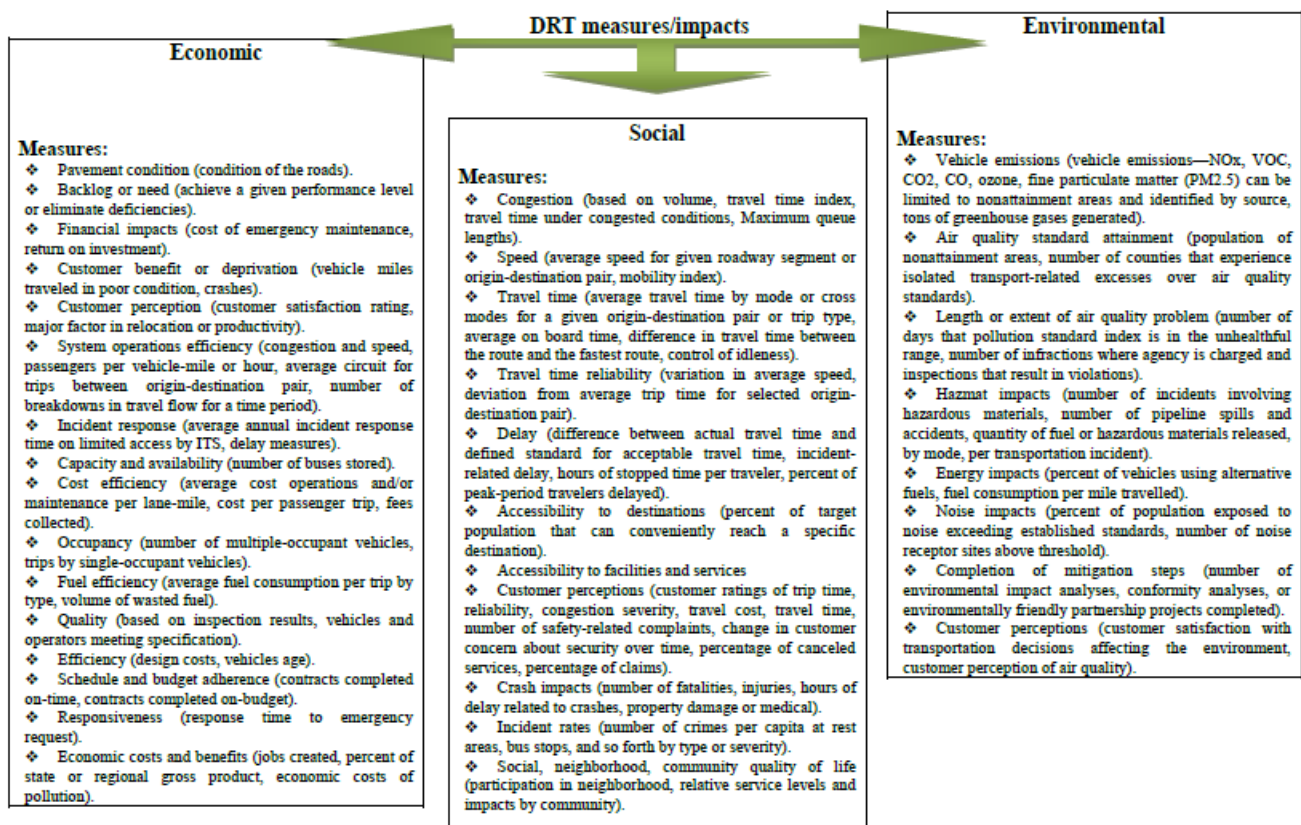


Figure 3: DRT impacts and Measures (adapted from NCHRP, 2006).

CONCLUSIONS AND FUTURE WORK

The objective of this research work was to develop a systematic analysis of the main issues that should be addressed when evaluating transport investments, in particular those related to the adoption of flexible transportation systems such as Demand Responsive Transportation (DRT) systems.

Transport systems costs structure were reviewed and discussed and a classification of costs attributes was proposed. The literature reviewed allowed the identification of the complexity of the evaluation process and the lack of comprehensive and satisfactory approaches to the problem.

Specific characteristics of DRT systems were analyzed and the three most relevant impacts that must be considered: economic, social and environmental were considered. A framework of performance indicators was identified as essential to the evaluation process.

Based on the literature review carried out and on the indicators identified, our proposal consists in developing a framework to perform an economic evaluation of such a transportation system at the design phase of the project. Since the outcome of the evaluation is highly dependent on the DRT specification (in terms of operational parameters, such as the level of spatial and temporal flexibility of their services), this framework must comprise an iterative approach that consists on defining an initial DRT specification, estimating their impacts in terms of performance indicators, redefining the specification and re-estimating the new impacts, and so on until a suitable solution is found, in terms of technical and economic viability and sustainability. The estimating of the impacts of the alternative DRT specifications can be performed by using a computerized simulator that makes the interaction between the demand (customers) and the supply (vehicles and system coordinator) at the individual level thus capturing the proper dynamics of the system.

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ON THE SOCIAL RETURN OF R&D PROJECTS AND SUPPORT PROGRAMMES

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KEYWORDS

Social Return, R&D Projects, Support Programmes

ABSTRACT

This work is a part of an ongoing research focusing on the social impact of R&D projects and support programmes from the perspectives of the public and private sectors. The research project is based on interviews conducted as part of a case study methodology involving a marine-sector private company and the Technological Center in Vigo. The results indicate that the criteria chosen as being the most important for the evaluation of social return of R&D were the number of jobs created at the company, the environmental impact and the working conditions. Also included in the analysis were the criteria used in the process of evaluating applications for funding. From the analysis it becomes notorious that social return is not a priority in this evaluation process, with assigned weights for the related criteria ranging between 0 and -22%. The only exception was the Transnational Program of cooperation Atlantic Space where the weights of the variable related to the social character of the project sum about 50 %. The mostly used criteria are the environmental impact, the incorporation of new PhD's and the presence of women investigator's in the project. Only in the Transnational Program of cooperation Atlantic Space include criteria like the transference of knowledge, diffusion of knowledge and platform growth.

INTRODUCTION

From the point of view of the private companies, several studies show that evaluating R&D projects is a complicated task as Mohanty et al.(2005) argue. But, although these difficulties exist, these evaluations are fundamental due to the competitive environment surrounding R&D investing companies.

These evaluations are supposed to focus not only on purely financial factors, but also on the social criteria, with the aim of quantifying the of social return and ensuring that adequate levels of social return are

obtained in R&D activities financed by private corporations or public agencies.

The first fruits of this project suggest an obvious interest from the participants in these projects and programmes. However, they expose also the difficulties of obtaining information and setting a common methodology that would allow to contribute for the measurement of the efficiency of those projects and/ or programmes using a consistent form (Carvalho, 2009; Álvarez Gómez, 2009).

The lack of objective measures increases the evaluation time and may lead to the lack of R&D investment because the interest of the theme is not clearly demonstrated (Sánchez and Pérez, 2002). In spite of the difficulties of the process, the definition of a methodology for the selection of R&D projects is fundamental. Different methods of evaluation have been reported, most of them based on purely financial tools, cost-benefit analysis or some kind of multi-criteria model. These last ones, allows for the inclusion of criteria like lucre, business relevance, probability of technical and commercial success, among others (Eliat et al., 2005).

From the point of view of the evaluation of programmes which support R&D activities, it is appropriate to say that different methods exist as Cozzarin ,(2006) or Ruegg and Feller, (2003) studies stand out.

EVALUATION OF R&D PROJECTS AND PROGRAMMES

This section intends to demonstrate the importance of a correct evaluation of R&D projects for companies, analyzing in particular if and how companies measure the impact of R&D activities.

Mohanty et al.(2005) support the need for a compatibility between the R&D project and the company mission, underlying also that companies are supposed to foresee the obtained benefits. The authors demonstrate the importance of the selection process of R&D projects, due to the underlying risks that may generate important losses in financial results and in human resources.

Loch and Tapper (2002) identify the most important objectives to control the performance of R&D: Aligning

behavior and installing priorities, establishing a working control, stimulating, learning and getting better. Also Chiesa et al. (2009) justifies the importance of R&D performance measurement: Motivating researchers and engineers and improving their performance, controlling the progress of R&D activities regarding objectives of resources consumption, time and technical requirements, evaluating the cost-reducing contribution of R&D activities to the company, reducing the uncertainty and promoting organizational learning.

Next section presents different methods that were used in the evaluation of programmes supporting R&D activities and also in the evaluation of R&D projects at company level, focusing in particular on the possible inclusion of social criteria in these evaluations.

Methods of evaluation at company level

Chiasse et al., (2009) study aimed to discuss the problem of the measurement of the performance of R&D activities at company level. The used methodology was based on a framework identifying : (I) the main contextual factors and the approaches used to measure the performance of R&D activities (II) the main issues that would have to be taken into account when designing a performance measurement system (for example indicators). The proposed framework was applied in multiple case studies, resorting to interviews as research method .In order to measure the performance of R&D projects the indicators of financial type like the IRR (Internal Rate of Return) and NPV (Net Present Value) were used. In addition other indicators included the share of new products sales, number of presented complaints or customer satisfaction, registered patents, number of publications and number of new ideas per year, among other ones.

Mohanty et al, (2005) resourced to the ANP process (analytical net process) with a partial cost analysis for the selection and evaluation of R&D projects. The authors used a large range of criteria such as the strategic adjustment, the capacity, the technical viability, the financing, the risks, the organizational preparation (culture), the opportunity costs, the duration of the project, among others.

Eilat et al. (2008) presented a method for R&D evaluation, based on a multi-criteria model. The proposed indicators offer an evaluation of the performance of the organization taking into account the financial and commercial perspective along with the operational and strategic dimensions. Sánchez and Pérez (2002) demonstrated that ratios and the financial analysis of the project are the most common evaluation methods.

Methods of evaluation of R&D support programmes

Ruegg and Feller (2003) describe different kinds of methodologies for the evaluation of programs such as: The analytical method and the conceptual- model of the

subjacent theory, econometric and statistical method ,survey, the case study, the analysis metric and social-nets member, historical tracking and expert's opinion.

An interesting study that tackles this theme is presented by Cozzarin (2006). The author presents 11 programmes which support R&D activities from the Government of Canada and describes a method of analysis to see the economic and social impact. A large number of methods was proposed to analyze these programmes such as: Internal Rate of Return (IRR), the Cost-Benefit Analysis (ACB), Econometric studies, and Microeconomic Analysis. The author proposes also the inclusion of a set of non-financial indicators, turning the analysis more complete and focusing it towards the concept of social return.

Another recent work of investigation conducted by Carvalho (2009), presents an analysis of different programs of public financing for Portugal in the R&D area. In order to be able to accomplish a comparison among these programmes, a set of qualitative and quantitatively indicators that can characterize the attained objectives was used. From the quantitative results of the interviews with experts the order of importance of the considered criteria was derived: Formation, conditions of employment, ambient/ energy, social return against financial return, job and finally the return on investment.

Selection of indicators

To proceed with the empirical study a selection of indicators directly related with relevant criteria to the assessment of the social return of R&D programmes was attempt. This selection of indicators was based on the presented bibliography, on other references (Ares et al., 2008), (Carvalho, 2009), (Álvarez Gómez, 2009) and also on to the Spanish Observatory of the Invention and of Knowledge (ICONO) web page. The selected category of indicators are: Employment/ Working conditions/ Learning and growth/ Return social vs. financial Return /Environmental Effects /Investment taxes.

For each one of these categories, a set of indicators was proposed:

Employment: Creation of employment: increase of the total number of places of work in the company/ Creation of employment: increase of the total number of places out of the company/ Increase of the number of places of work for disadvantaged communities socially, women, immigrant..

Working conditions: Quality employ-ergonomics/Wage level/Level of training: increase of knowledge and capacities /Security/Degree of satisfaction of the employees/Good working environment/Maintenance and consolidation of existent places.

Learning and growth: Improvement of the competitions of the R&D personnel /Boost the culture of R&D/ Diffusion of knowledge (scholarships, patents)/

Creation of spin-off (number of companies created from the knowledge obtained by the project and that are kept independent /Transfer of knowledge Know-Hw/Platform for the growth.

Social Return: Improvement of the social satisfaction/Resolution of problems like unemployment, delinquency, immigration/Contribution for the regional development/Contribution for national politics, regional or European/social Effect in the operation of market: transfer of companies, outsourcing, boost the spirit of the technological innovation.

Financial Return: Increase of the productivity for the company /Increase of the quota of market/Reduction of costs/Financial Stability of the company/Economic effect in the operation of market: creation of new companies, increase of the productivity/Sales of new products.

Environmental effects: Reduction of the pollution, broadcasts/Protection of the environment/Reduction of the energetic consumption/ Utilization of renewable energy sources.

Investment rate: New buildings/ Infrastructures of I+D+i/Investments in human capital (education, human skills, academic methods).

EMPIRICAL STUDY

The empirical study presented in this research paper, is centered at the marine sector. A case study methodology will be followed, describing opinions of a private company operating in the sector (Ronautica, SA) and of the Technological Center of the Sea (CETMAR). The case study methodology was utilized previously in works such as Chiesa et al, (2009) and Carvalho, (2009) also focusing on the evaluation of R&D projects and programmes .

This interviews conducted aimed to collect opinions on the social impact and social return of R&D. The format of the interviews conducted was based on Foddy, (1995).Both organizations included in the research were involved in R&D projects financed with public funds. The main objectives of the empirical study were: (1) to determine which of the proposed indicators are assumed to be more important for project evaluation and how this indicators may be associated to the concept of social return,; (2) to assess the importance of this social return concept on the moment of project elaboration.

Analysis of results

Qualitative Analysis

The qualitative analysis of this interviews aims to collect information about R&D projects in general and to the evaluation conducted at the company or at the technological center. Some general information could be drawn from the interviews results:

1) Difficulties in getting financing: Both interviewees emphasize that there are always difficulties at the

moment of getting financing and on the electability of the expenses. This may even lead to the impossibility of conducting the project.

2) Social objectives: The company does not deal with social objectives during the project evaluation. In fact, for 95% of the company's projects, most of the objectives focus on the financial character. The environmental benefits that the company gets from the creation of new and more ecological products and environmental friendly processes are frequently collateral consequences of the project and not pre-defined objectives. The Technological Center, however, gives more attention to social objectives of the project during the project follow-up and evaluation. Neither the analyzed company nor the technological center resource to a predefined set of indicators to evaluate the impact of R&D projects.

Quantitative Analysis

This quantitative analysis aims to establish a ranking of the indicators that could evaluate the social return of a publicly funded project. This ranking was based on the weights assigned by the company and by the technological center.

From the private company point of view the main indicators that could be used to evaluate social return are, in order of importance:

1^o employment and in particular the most notable indicator is "creation of employment: increase of the total number of places of job in the company".

2^o environmental impact and in particular the most important indicator is "utilization of renewable energy sources".

3^o working conditions and in particular the most important indicators are "level of training: increase of knowledges and capacities (polyvalence)/ security/ degree of satisfaction of the employees".

From the technological center point of view the main indicators that could be used to evaluate social return are, in order of importance:

1^o Employment ("creation of employment: increase of the total number of places of work in the company"). Learning and growth ("knowledge production")/ Working conditions ("polyvalence)/ Security/ Degree of satisfaction of the employees.") Environmental impact ("Reduction of the pollution, broadcasts/Protection of the environment/Reduction of the energetic consumption/ Utilization of sources of renewable energy" (all considered equally important).

2^o Social return vs. the financial return.

For the social return the most notable indicators are - Resolution of problems like unemployment, relocation, delinquency, immigration/ Contribution to the regional development/ Contribution to national, regional or European politics, all valued with the same weight.

For the financial return the most important indicators are: Increase of the productivity for the company/
Economic effect in the operation of market: creation of new companies, increase of the productivity, also valued with the same weight.

3° Investment return.

Analysis of the company's R&D financial sources

In this section the evaluation criteria included in the public calls of Support programmes in which the company R&D projects were included will be analysed. The project data were taken from the website www.ronautica.com

Project1, under PGIDIT 2006-2010. Code: IN841C-2006/314

The objective of the call was to promote business innovation in the Autonomous Community of Galicia. Included criteria were: environmental implications, significant pollution reduction, reduction of energy consumption, importance and capacity of the Project to solve problems in the sector (maximum 14 points over 100) and creation of new jobs and significant presence women on the team (máximum 8 points over 100). In total, the assigned social value was 22%. The technical criterion was worth 50%.

Project 2, under PGIDIT 2006-2010. Code PGIDIT06CCP007.

This included public calls from sectoral programs of Natural Resources, Innovation Technologies and Services. The only criterion related to the social impact is the significant presence of women researchers in the research team with 2 points assigned out of 100. So 2% of the evaluated related to the social value. The scientific and technical criterion was the most important one weighting 70% of the overall evaluation.

Project 3, under PGIDIT 1999-2001 and 2002-2005. Code PGIDT01MAR05Y.

This call related to the Plan Marino Gallego Research to the Research Program and Technological Development. No evaluation criteria related to the social impact was found.

Project 4, under PGIDIT 1999-2001. Code PGIDT00INN33Y

This was included in a public call from the Support Program to Innovation of Plan Gallego for Research and Technological Development. Once more, this call does not include any social criteria for the evaluation.

Analysis of the Technological Centre R&D financial sources

The technological centre projects address mainly Control and Management of coastal and marine

resources, project objectives can be found at its website: www.cetmar.org

Project 1, funding: European Union. Multinational Cooperation Programme Atlantic Area. Social indicators displayed on the call are: Extent to which the project responds to challenges common to all the territory of the Atlantic Area. Weight 7/100.

Positioning of the project in an ascending scale of four levels of intensity of cooperation: exchange of experiences, knowledge transfer, sharing of resources and problems solving, development of a transnational strategy. Weight 7/100.

Demonstration of the sustainability strategy of the project to allow to proceed with the project activity beyond the funding period, including the possible leverage effect through the involvement of new actors, sectors or regions. Weight 6 / 100.

Relevance and realism of the communication plan and its contribution to the transferability of the results of the project including the transfer of knowledge and best practices to expand the Atlantic Area (for new audiences, sectors or regions). Weight 6/100.

Relevance, realism, and tangible value of performance indicators and results and their relation to the objectives of the project. Relevance of monitoring indicators presented. Weight 6/100.

Extent to which the project demonstrates, through information, such as the issues and challenges of the project correspond to the objectives and problems common to Member States / regions of the Atlantic Area. Weight 5 / 100.

Extent to which the project promotes and facilitates the transfer of knowledge and know-how and exchange of experiences within the partnership. Weight 4 / 100.

These indicators represent a weight of 50% compared to the total. Each project is graded between 0 and 5 for each of the twenty criteria that may be found in the Candidate Handbook from the website (<http://atlanticarea.inescporto.pt/>).

Project 2, Financing: General Direction of R&D. Ministry of Economy and Industry. Plano INCITE - Eranet AMPERA (VI Marco Program). Xunta de Galicia.

The most valuable criterion in this case is the scientific and technical merit with a maximum of 70 points out of 100. Those criteria that may be included in a social category are: number of PhD, incorporation of new PhD, balanced participation of women researchers in, with a maximum of 4 points on 100. Use of Galician language with 2.5 points out of 100. This represents a total of 6.5% in social valuation. Project 3, Funding: Ministry of the Sea .Xunta de Galicia.

Social criteria pre-defined in the order of October 20, 2008 are the criteria for test methods to improve gear selectivity of fishing and environmental impact with 8

points on 100 and follow good environmental practices with a weight of 2 points on 100. This implies that social value is 10% of the total. The most valued is the scientific-technical quality and innovation with a weight of 40% of the total.

CONCLUSIONS AND FURTHER RESEARCH

The main aim of this paper was to establish a set of variables or indicators that can be used to assess the social return of R&D. Therefore a set of criteria or indicators to prioritize the social return more than economic or scientific were chosen. Based on these criteria, interviews were conducted to assess the possible social return generated by R&D. The interview was conducted in a marine sector company and in the technology centre of the sea. Following the interviews and according to these case studies, it seems that this company does not take into account social objectives when carrying out projects. The technology centre, however, takes already into account some social objectives when elaborating and evaluating their projects. However, both interviewees have a limited idea of what is the social return and what criteria may be used to measure, indicating a clear lack of awareness to that concept. The criteria the interviewee selected as most important for evaluating the social returns are the employment with Number of jobs created in the company, the environmental and working conditions. After analyzing the calls to the R&D support programmes, it could be concluded that a match seems to exist between the criteria that the firm and technological center consider to be related and/or assume to be important to measure the social return, and the criteria included in the R&D support programme calls. Taking this into account the possibility that a relationship may exist between the social criteria that are required in the calls and the concept of social return for companies and agencies, the following hypothesis may be proposed:

“these social criteria appearing in the calls can influence business objectives and agencies applying to the support programme. Companies frequently prepare the project by finding the lines of the call that best suits the companies’ needs and characteristics, so if the call requires environmental objectives the project will end up having environmental improvements. That is, there is a possibility that setting a greater number of social criteria for project evaluation under a specific R&D support programme, will lead to increase awareness for social return on the company goals and to the need to accomplish predefined minimum social goals.”

To test this hypothesis more interviews and in deep analyze of public R&D support programmes calls seems to be fundamental. It must be underlined that the

discussed result represent the point of view of the interviewees and may not be universally accepted. In fact, the conclusions drawn from a case study cannot be generalized (Gable, 1994). But as Benbasat et al., (1987) underline the case study methodology can generate theory from the practice.

If the weight assigned to the social criteria of each call was to be associated to the potential social return generated by the project, we can conclude that from all analyzed calls, the one with the highest potential social return is the Transnational Cooperation Programme with almost 50% of total evaluation weights assigned to social criteria. This hypothesis should also be studied further. For this more calls must be analyzed getting also data on the social impacts generated by the projects supported by these calls.

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USING EXPERT INTERVIEWS TO CREATE ELECTRICITY SCENARIOS AND TO ASSESS SOCIAL IMPACTS

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KEYWORDS

Scenario building, Social impact assessment, Expert interview

ABSTRACT

This paper focus on the assessment of the social dimension of electricity planning, resorting to participative methodologies. A guide for interviewing power systems experts, covering a wide range of themes is presented. The guide focus on evolution of electricity consumption and supply according to each type of technology, driving forces among emerging technologies, energy policy, the relevance of sustainable development among institutions and markets and, finally, a first impression on the relevance of social impacts for candidate technologies. The main aim of the methodology is to gather discourses among experts and try to understand the connection between narratives and their consequences on the best scenarios under the social point of view. Therefore, the interview uses both quantitative and qualitative questions. The former are used for creating electricity generation scenarios within a 10 year range, while the latter aim at gathering each position's underlying explanations, which will be useful for cluster analysis in future work. The results presented in this paper refer to interviews which took place among the members of the working group of the project "Sustainable Electricity Power Planning".

INTRODUCTION

In 1997, the Kyoto Protocol was adopted. One decade later, the European Union proposed the so-called "20-20-20" package, which goals are (i) to cut in greenhouse gases (GHG) emissions to at least 20% below the 1990 levels, (ii) to reach 20% of renewables share in the energy mix and (iii) to cut 20% in primary energy consumption, until 2020. The electricity sector is of major importance for the energy decision makers, as it accounts with, roughly 20% of the total energy consumed in the aggregate of the 27 countries of the EU (Data retrieved from <http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/introduction>). Also, it still relies mainly on fossil fuel power plants responsible for high GHG emissions.

Besides the fact that some of these older power plants are to be decommissioned within the next decade, the consumption of energy is also expected to increase around 15% during this period (European Commission, 2008). Therefore, replacing and installing new power plants must involve decisions integrating the social, economic and environmental concerns, or in other words, sustainable electricity power planning is a key issue for all the EU members.

The EU members also follow the so-called EU Sustainable Development Strategy (EUSDS), which underlines the importance of the social concerns, besides the economic and environmental ones. Given the complexity and the importance of the electricity sector, new planning models have to be formulated addressing these concerns.

In a previous work, the authors surveyed papers addressing social concerns in power systems decision-making (Ribeiro et al. 2011). Among these papers, several relied on expert participation; however only one of them (Kowalski, et al., 2009) used that knowledge to create scenarios.

According to Maitima (2007), scenarios are "statements that paint a broad but relatively shallow picture of possible futures" and are traditionally regarded as a powerful tool for long-term planning. Holland (2007) argues that scenario analysis can be used to analyse major changes in strategic direction. Given all the institutional changes, in the past years, of the electricity sector (liberalization, feed-in tariffs, national plans for hydropower, an ever growing increase in renewables share, among others) this scenario analysis can supply valuable information to be included in power system planning.

This study presents an ongoing research project based on interviews with experts focusing on future electricity scenarios. Thus, the main objectives of the interviews are: (i) to formulate more likely to happen scenarios according to the experts views, (ii) to formulate the most desirable scenario, according to social criteria and their relative (therefore subjective) importance (iii) to collect experts opinions on institutional and technological driving forces for the electricity sector.

The Portuguese electricity sector context is presented in Section 2 and the guide for the interviews is described in Section 3. The results obtained with a pilot group are

presented in Section 4, followed by conclusions and guidelines for future work in Section 5.

THE PORTUGUESE ELECTRICITY SECTOR

Portugal stands as a strongly energy dependent country, having imported 83.3% of its total primary energy in 2008 (Data retrieved from <http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/introduction>).

The Portuguese electricity power generation can be described in short: coal serves as base load due to its technological nature (long startup and shutdown times), whereas combined cycle gas plants cover also base and peak demand, along with hydropower. Installed wind power capacity has increased lately and due to its nature it is not dispatchable. The dependency on hydropower can be noted when comparing wet and dry years: in 2003 (a wet year) the hydro electricity production was 16TWh, whereas 2005 (dry) was 5TWh (Data retrieved from

<http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/introduction>). Hydropower covered 11% of the total electricity consumption in the dry year, and 37% in the wet one (own elaboration of data from <http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/introduction>).

The electricity production is divided in two regimes: the ordinary regime competing in market (traditional sources like thermal and large hydro) and special regime production (SRP) paid according to feed-in tariffs (endogenous and renewable energy sources).

Figure 1 gives details on the production of energy in 2010 by source, and also the importation ratio. It should be taken into account that 2010 may be considered a wet year, resulting than in hydroelectricity generation above the average.

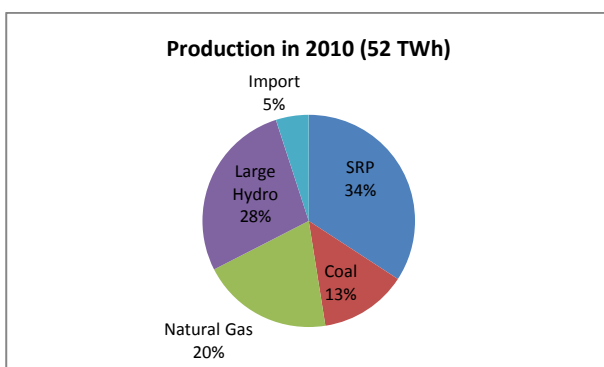


Figure 1: Production of Electricity in Portugal, 2010
(Source: own elaboration from www.ren.pt data)

In 2000, the SRP represented 10% of the total energy produced. This value reached 33.9% in 2010. Wind power increase represented the most important contribution to this new SRP shares, along with “other cogeneration” (mainly at industries level)).

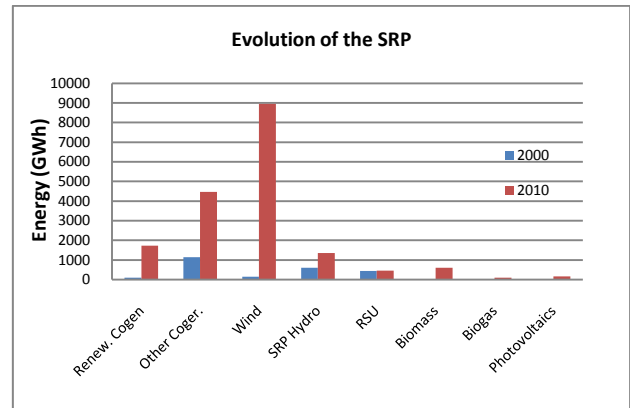


Figure 2: Evolution of the Special Regime Production in Portugal (Source: own elaboration from www.dgeg.pt)

THE INTERVIEW GUIDE

The interviews referred in this paper took place during March 2011. A pilot group was prepared and researchers involved in the project Sustainable Electricity Power Planning (<http://sepp.dps.uminho.pt/>) were included in this first approach. The main objective was the interview guide validation but is also possible already to test the dissimilarities among the respondents' perceptions.

The guide is divided in eight sections, as follows.

Presentation of the Project. A brief introduction to the Sustainable Electricity Power Planning project is made, as well as the purposes of the interview. The same information is to be used when contacting the experts in future work, in order to trigger either their enthusiasm or unwillingness to participate.

Electricity Consumption Ratio. How will the electricity consumption evolve in Portugal within the next 10 years? What reasoning is behind that perception? Official estimates by REN (Portuguese Transmission System Operator) are given. It is also asked whether the electric vehicles will influence these numbers.

Evolution of the Supply. Given the data presented in Figure 1, perceptions on the most probable scenario in 10 years are asked. The REN forecasts for 2020 are also presented. Evolution on the import ratio, and driving forces, are also asked. The possibility of having nuclear power in the mix, and respective share are also asked.

Evolution of the Special Regime Production (SRP). This and the last section were separated to avoid an information overload in each section. Main driving forces at technological level are asked. Perceptions are also asked on mature technologies which could be further implemented and become relevant.

Sustainable Development now and in the future: Some social sustainable development definitions are given, and the European Sustainable Development Strategy is presented. Perceptions on the importance of the theme are asked, for now and for the future. Examples of economic and environmental tools are named. Tools suitable for optimization under the social

point of view are asked, as well the relevance of choosing to do so.

Social Impacts Associated With Each Technology.

Too much information would have to be asked in order to have a complete picture of social impacts associated with each technology. Also, it is still not clear whether the list of presented impacts is complete, so the interviewees are told that a more complete or even alternative method would have to be presented in a subsequent phase of the project. So, the interviewer mentions all the impacts that were collected in previous literature review, and asks if some further impacts are missing. Thus, for each impact, the relative importance is asked. The more important impacts (either positive or negative) variations are asked for the different technologies. The conversations are recorded, and it is expected that some patterns arise in the narratives.

Best “Social Scenario for 2020”. The interviewee must now construct a supply scenario according to the perception of what he mentioned that was important in strictly social terms. The interviewee is told that uninstalling power is possible – for example “shut down the coal power plants” – as long he feels that all the conditions of delivering the entire load are met. From these topics it will hopefully be possible to understand relations of discourses and shares of energy per technology.

Energy Policy. This topic covers the opinion on the possibility for renewable sources to become competitive outside any kind of tariffs or subsidies. A thought on actual policies is asked, as well as if the “Social Best Scenario for 2020” would be possible in this context.

RESULTS

We present now an overview of the most relevant results. For more detailed data, see Appendix.

Evolution of the consumption and production

There is a divergence among the responses about the evolution of the expected load. Half of the respondents believe that the annual growth rate of 4,4% (estimated by REN) is to be met, while the others, referring explicitly the uncertainties related to the future of the crisis and consequences on the industry, remain less optimistic and have given lower values (2%, 2,5% and 3%). While REN expects the consumption in 2020 to be 80 TWh, our results point to the arithmetic mean (X) of 73.87 TWh, with standard deviation (σ) = 7,43 TWh; which is translated to a growth ratio with X = 3.45% and σ = 1.087%.

Only two respondents believe that the import ratio is expected to rise in absolute (TWh) numbers, but everyone expects it to be equal or lower than the relative ratio of 2010, which was 5%.

Figure 3 values are in relative numbers (i.e. relative to each column load forecast). Absolute numbers of expected electricity production can be found in Appendix.

All the collected opinions agree that SRP will increase both in absolute and relative numbers, when compared to 2010 values. The arithmetic mean for the relative values is 51%, which lies between the REN scenarios (46% and 54% in the reference and 20-20-20 scenarios, respectively). In terms of absolute numbers, we obtained X=37,6TWh with σ =4,4%.

If compared to a regular year in terms of hydraulicity the large hydro production all the responses point a slight increase in the large hydro production absolute numbers (from 11,7 TWh to X=14.9 TWh and σ =0.89) and decrease in relative terms (24% in 2010, and 2020 forecast X=20,2% with σ =2,1%).

Both REN's scenarios point 15% (12TWh) of coal production, but interviews results were fairly lower: 8,1TWh (10,9%) and σ =2,2 TWh (2,14%).

Natural gas is very volatile in REN's forecasts, with a share of 12% in 20-20-20 and 21% in Reference scenarios. The interviews results pointed to X=11,2 TWh (14,9%) and σ =3,98 TWh (4,5%).

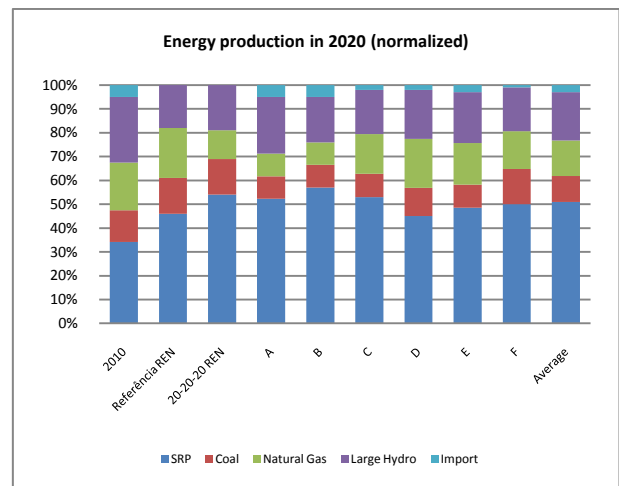


Figure 3: Energy Production Shares depending on Technologies. 2010 values, REN's Scenarios and Interviewee's Perspectives

The interviewees believe that nuclear power is definitely not going to be an option: planning and building a nuclear power plant takes 10 years, which is the forecasted period (B, C and F) and although some pressure groups are trying to implement it (B), there is not yet public debate over this issue (A). The recent Fukushima disaster and its unpredictable consequences are having a negative influence in public opinion (C), although historically, building one single large hydropower plant probable killed more workers than nuclear power plants in its history (F).

The electrical vehicles will remain either as marginal within ten years (B, E, F) or may contribute to a small but not negligible increase in the annual load (A, C, D) especially in off-peak hours (C).

We could resume our average results (with normalized values) as follows: thermal power (coal plus natural gas) to decrease from 33% in 2010 to 26% in 2020 while some new hydropower is produced but the relative share diminishes almost 5%; these reduction factors are compensated by SRP. In absolute numbers, most of the uncertainty is the value of the SRP ($\sigma=4.4$ TWh) followed by natural gas ($\sigma=4$ TWh).

The expected SRP production for 2010 and 2020, in relative terms of each respondent's total SRP forecast, is presented in Figure 4.

If we average the absolute results from the interviews, the SRP in 2020 would double the 2010 value (17.8 TWh to 37.3 TWh, $\sigma=4.39$). Most of the uncertainty comes from wind power, which will still be leading, with a share close to the one in 2010 (from 50.1% to $X=48\%$, $\sigma=7\%$). Non-renewable cogeneration explains some variation, with $\sigma=6.3\%$ and $X=19\%$. Photovoltaic's received some contradictory results, either being considered not to increase at all (A) or to increase 15 times its amount of energy produced (F) which gave results to $\sigma=1.24$ TWh. Still, its share is never foreseeable to be greater than 8% of the SRP and could be as small as 0,6%.

The only "new" technology mentioned was solar thermal (B, C and F), never exceeding 500 GWh, or 1.3%. B and C pointed that photovoltaics would produce as much as solar thermal.

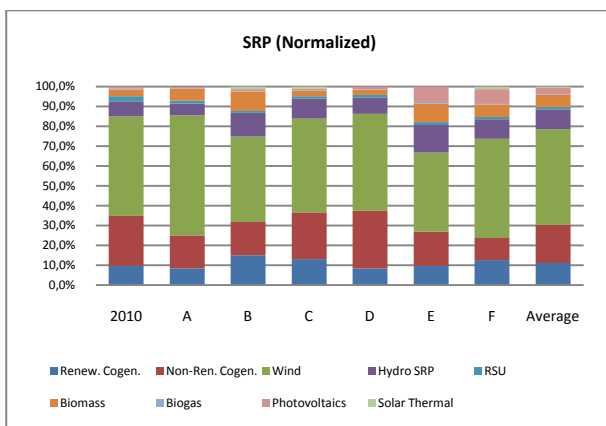


Figure 4: Shares of Special Regime Production in 2010 and what Interviewees' Expect for 2020

Social sustainability and the "social best" scenario

Sustainable Development is gaining recognition but mainly at environmental level (A, B, C). All the interviewees are optimistic about the relevance of the concept in the near future.

It is very difficult to separate the social and the economic dimensions of Sustainable Development (A, B, D, and E). Therefore, some reward mechanisms should be implemented every time a project of electricity generation is to be done, as it happens with wind power projects, whereas certain amount of money is to be invested in the nearby communities (A, E).

The analysis of externalities (e.g. the ExternE project) and their valuation may find values for calculating subsidies or at least to make the problem possible to be optimized when minimizing the total costs (A, B). There is not a foreseeable international (or at least European) agreement for the social dimension as there was for the environmental one, i.e. the carbon market, because often the impacts are more regional or local (A).

Decision-makers should rely on Multi-Criteria Decision Making, in the view of C, which leads definitely to a difficult task given the economic dimension within the social choice: Willingness-to-Pay methodology should be used to address trade-offs, although when the economic conjuncture is going through difficult times it is rather probable that most of the population is not willing to pay more on short term on the electricity bill (C).

The central planning authorities should favor the poorest regions when planning, having in mind a redistribution of wealth within the countries, which brings cohesion and avoids migration, an important issue at least for Portugal (D).

Public opinion studies and the variability of opinions after the implementation of information campaigns can be valuable for a central planner, but the collision with the economic dimension is inevitable (E).

Job creation appears to be a good thing at first sight but, according to F, a simple example proves how can be arguable: company X and Y have the same initial investment, as well as operation and maintenance costs and sell electricity at the same price; the only difference is that X employs 10 workers, whereas Y employs 100. "It is true that the total profit is split, in company Y, among a greater quantity of people, but at the same time the workers are not being productive in other companies, where they could be creating more value for the whole society" (F).

Next the "Social Best" scenario is presented in relative values (to each interviewee's forecast of load). We try to identify, in the discourse of the interviewees, the driving forces which led to the results. In Appendix it is possible to find the results for each interviewee in separate.

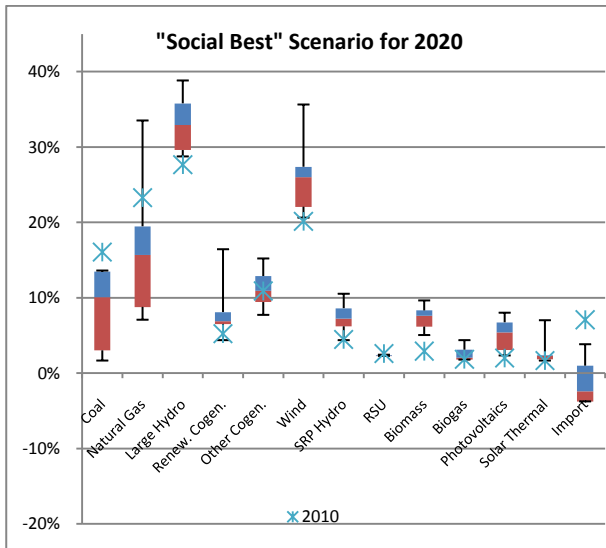


Figure 5: Social Best Scenario for 2020

A brief resume of the average results can be: comparatively to 2010 values there is the general idea to see an increase on wind power (17% to X=22.6%) and total hydro, i.e. large plus SRP (from 26.6% to X=34.3%) for a social best scenario. This increase (+13.2%) is mainly compensated by the loss of generation in thermal units (-13.3%): interviewees appear to wish coal and natural gas to fall from 13% and 20%, respectively, in 2010, to X=6.3% and 13.7%.

Most interviewees believe that the import ratio, should decrease in a social best scenario and rather become negative with an average result of exporting 3%, rather than importing 5% as in 2010. This implies that increasing electricity generation besides the natural evolution of electricity consumption would be required. There is a common idea that increasing SRP renewables would lead to social best scenarios: solar (PV and solar thermal) together with biomass and renewable cogeneration, represented 4.8% in 2010 and X=15.7% was obtained as social optimal value in 2020.

The most contradictory answers are related to natural gas, for which the standard deviation was 9.1%.

The set of criteria related to the social impacts of electricity generation technologies presented to the interviewees included: 1. Visual intrusion, 2. Public health harm, 3. Direct job creation, 4. Indirect job creation, 5. Energetic independence, 6. Investment, 7. Social cohesion, 8. Income by land use, 9. Noise, 10. Road construction on remote places, 11. Resource management, 12. Development of rural areas, 13. Solid waste production, 14. Envolvement of local actors in the project.

The interviewees felt that no additional criteria was missing (according to E, impacts on ecosystems could be included, but that can also be considered more an environmental problem than a social one). Each discourses towards the criteria will be described next.

A: Optimal social scenario is somewhere near REN's 20-20-20. Thermal units would lose relative weight because A very clearly stated that energetic independence is definitely the most important criterion: coal is maintained, whereas natural gas would be reduced also in absolute numbers (it is yet utopian to believe we can quit thermal units). SRP is the same as the 20-20-20 scenario, while hydro, instead 19%, is pointed to be 32%. SRP, photovoltaics, biomass and renewable cogeneration result in 14% where they represented 4.8%. Exporting 5% becomes possible. Both direct and indirect job production are very relevant criteria, being the latter the one in which renewables have higher impact (A mentioned the Portuguese wind power cluster as "very important at the economic level"). Although dams and wind turbines have high visual impacts, this is considered not to be a relevant issue, which can perhaps gain significance when the wind share grows much higher. Investment is seen as a very relevant criteria but it is less crucial than energetic independence. On the rest of the criteria, a positive note on biomass was mentioned on several criteria, even if none of them was considered to be as crucial as the already mentioned before: income of land use (very positive for wind power also), road building, resource management (better use of forest) and rural areas development.

B: Optimal scenario uninstalls all the coal power and favours instead 26% of large hydro power production and 8% SRP hydro, which must be combined with large wind energy production (31%). Biomass can cover 7% of the whole production, and renewable cogeneration 14%. Natural gas covers naturally peak load, and is kept on 5%. Exporting 5% becomes possible, given the large wind power installed and it is very subject to vary from year to year due to the high dependence on hydro power.

Among the criteria, both energy independence and job (direct and indirect) play a major role for what can be seen as public investment (even if assuming the form of subsidies) to recover from the crisis in long term. Resource management, combined with income from land use can be used in a national plan for biomass to avoid migration and develop rural areas, assuming ultimately the form of a geographical distribution of wealth. The rest of the criteria are irrelevant.

C: Best social scenario is clearly headed towards SRP, which assume 65% of the whole production. Both coal and natural gas contribute with 5% of the total production, and large hydro 25%. Within the SRP, wind power leads with 24%, followed by other cogeneration with 13%. Solar power assumes 10% equally split between solar and photovoltaics. It implies a null import ratio.

Indirect job creation is very relevant and the Portuguese wind power cluster, with its very positive associated economic effects, was mentioned. Energetic

independence is not seen as a key issue, since Portugal produces much of its own electricity. Social cohesion can be important for renewables, since they generate a very positive effect in mentality in the whole population. Land use income is seen as a key criterion for implementing distributed power plants such as biomass and wind power. Forest management is very important for other issues such as fires that disturb Portugal every summer, therefore positive for biomass.

D: Best social scenario involves no coal power generation, but natural gas receives a boost, for 29% (hence the high value for standard deviation on natural gas). Large hydro power production would assume 34% of the consumption, and SRP remains unchanged with 34%, wind power having a share of 18%. Biomass receives a boost, and would be up to 4%. Import ratio is diminished to 2%.

Job creation is very important, both in direct and indirect terms, and thermal units have more operation and maintenance than renewable ones. Given the endogenous resources (mainly hydro and wind) it is possible for Portugal to balance the net imports with exports; on the other hand we are committed to the 20-20-20 objectives and we should try to accomplish them. However, there must not be an obsession with the so-called “independence” since we are in a common market with Spain and if Spanish companies produce cheaper electricity, it is normal that the market favors them. Investment can be used to develop rural areas, being land income a very important criterion for renewables, mainly large hydro, wind and biomass.

E: In the best social scenario, coal and gas both play smaller role than in 2010 (total in 2010 was 33%, and social best would be 26%); large hydro deserves a similar share and 5% import gives place to 2.5% export, which implies a rise in SRP from 34% to 51%, mainly driven by hydro, biomass and photovoltaics (however when referring to absolute values and not shares, wind power has the most significant rise).

Direct jobs are probably overestimated for renewables, since most of them do not require much of operation and maintenance (large hydro, wind, solar, and so on), and indirect jobs probably are created in other countries (R&D and industrial production). Energetic independence is very important and must be fought over long term planning. Investment is high for renewables but if they are not implemented they will not be able to penetrate the markets, thus research and subsidies are still needed to compensate the higher costs. It is very important to use unproductive land, in underdeveloped areas, in a way it favors locals, as it happens with wind power currently. Building accesses, together with resource management is important in biomass, in a way that can be helpful to fight fires.

F: The best social scenario concentrates 11% in coal, 17% in natural gas and 32% in large hydro. Given the

high share of SRP (46%) the resulting export can result in 5%. Wind power should lead with 21%, solar power (mostly photovoltaics) should achieve 4.4%, biomass 3%, renewable cogeneration 6.25% and SRP hydro 5%. As mentioned before, job creation can actually be bad for overall country productivity, and this is the main divergence from this interviewee and the others (although F recognizes that during a crisis this could act as a lever...). Investment is a very relevant criterion and, even if renewables are more expensive, they should be seen from the long-term return point of view (which is connected to energetic independence) and it is a very complex issue to analyze.

Next question was about the competitiveness of SRP in 10 years, i.e. if they can be installed without being paid according to feed-in-tariffs. Each respondent except D believe that wind power will become competitive, since it is receiving massive investment in Europe, which allows economies of scale; R&D has been lowering turbine and tower production prices per energy generated. Therefore, in 10 years, it will be installed at a price which could be said “competitive”: B points that this happens by lowering the feed-in tariff to the average consumer price and not by competing in the market, since wind power is not dispatchable. However, given the decentralized character of wind power, C points out that extending the transmission grid will still have high costs. C expects solar power to lower significantly its costs in 10 years, but probably not enough to become competitive. D does not think any of the SRP will become competitive. E and F think that probably non-renewable cogeneration could be used without feed-in tariffs.

The last question was basically “how real is your social optimal scenario with the current feed-in tariffs”. C, B and F believe that their scenarios are not feasible mainly because biomass would require more incentives (a solution would be to articulate mechanisms with ones which favor a better forest management). B pointed out that his wind power values are way too high. A thinks that the social best is too optimistic towards renewables’ shares. D and E think his social best scenario is realistic.

CONCLUSIONS AND FURTHER RESEARCH

This paper used input from researchers currently working on the Sustainable Electricity Power Planning project, in order to validate the interview guide for the Portuguese power sector experts in the near future. Further interviews will permit a more profound result analysis and, from their aggregation, some patterns in the results will arise, which make clusters possible (Tapio 2005). For now, we used only averaged results and analysed divergence by standard deviation.

There is a divergence of opinions in the annual growth rate of electricity consumption and this affects all the subsequent results. For all the respondents the expected annual growth rate for electricity consumption in

Portugal is somewhere between 2% and 4,4%. All the interviewees agree that, in a 10 year range, SRP will increase and about half of the energy consumed in Portugal will come from these sources. Much of uncertainty lies in the values for natural gas, which is also evident from the two REN scenarios. There is overall agreement towards hydro power generation, which will represent about 20% of the total electricity generation in Portugal in 2020. Also, every interviewee agree that the importation ratio will not rise in 2020. Wind power will still dominate among SRP with a share closer than the one it has today (around 50% of SRP). Cogeneration will have about the same share as in 2010, with renewable cogeneration increasing slightly more than non-renewable.

As for what could be the best option from the social sustainability point of view, interviewees share some perceptions, namely the need to fight migration from rural and underdeveloped areas, where investment and land income become crucial. The energy types which are assumed to be key factors for the sustainability objectives are renewables in general (SRP and large hydro) with particular emphasis on wind and biomass. Also, it becomes evident that the higher the SRP share, the higher is the expected exportation of electricity and the lower is the expected production of thermal groups (natural gas and coal).

Comparing the average results of the expected production for 2020 and the social best scenario, the biggest difference is hydro power (20,2% in the former, 29% in the latter), whereas SRP are close to each other (expected 51%, social best 53.8%). Expected import share is 3% and the social best scenario corresponds to an exportation share of 2.6%.

For the social best scenario, every interviewee expects coal power share to become lower and, all but one of the interviewees, believe natural gas power share should be lower than its actual, too.

Within the SRP, it was found that the share of wind power is expected to surpass the social optimum (25% against 23%). Biomass, photovoltaics and solar thermal are the key technologies that somehow compensate this lower wind power share for the average social best scenario.

No impacts were seen as missing, except impact on ecosystems rather than just forest management. Some of the chosen criteria were seen as rather unimportant: visual impact appears to be only relevant for one interviewee and just in case that wind power keeps growing at the present rate. None of the technologies for electricity generation is assumed to be heavily harmful for public health. Social cohesion is seen as no important at all for all the interviewees except but one, which saw in it the opportunity for changing mentalities. Noise should not be annoying, except for people which can live near a wind park, which does not happen often. The possibility of building access to remote places seems to be relatively unimportant but beneficial, according to the obtained responses.

Resource management, development of rural areas and land income are related with each other, and can compensate higher investments given its redistribution of wealth effect. Solid waste seems to be a relevant matter for nuclear power. Involvement of local actors in the decision making process would only happen in cooperatives and appears very much the same as social cohesion.

The main divergence among the answers relates to job creation, which could be adverse from the country's productivity point of view (one interviewee), contrarily to the other five interviewees who believe that it also contributes for redistribution of wealth, which they saw definitely as a key to sustainability. Wind power and non-renewable cogeneration are the technologies believed to survive in 10 years without subsidies, but not by general agreement. Social scenarios are mostly seen as feasible within the frame of current feed-in-tariffs, except perhaps for high biomass rate which could be somehow complemented by other strategies.

The project will now proceed with further interviews targeting energy experts that although being directly involve in the thematic are not necessarily related to this project. The idea is to add additional insights to the results in order to detect patterns and resource to some statistical analysis of the results, although not envisaging yes the statistical representatives of the population.

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Expected Production in TWh											
	2010	Referência REN	20-20-20 REN	A	B	C	D	E	F	Average	Std. Dev.
SRP	17,8	36,8	43,2	33,1	41,8	42,3	36,1	32,3	40,0	37,6	4,4
Coal	6,9	12,0	12,0	6,0	7,0	7,8	9,4	6,5	11,9	8,1	2,2
Natural Gas	10,4	16,8	9,6	6,0	7,0	13,3	16,5	11,6	12,7	11,2	4,0
LargeHydro	14,3	14,4	15,2	15,1	13,9	14,9	16,5	14,2	14,6	14,9	0,9
Import	2,6			3,2	3,7	1,6	1,6	2,0	0,8	2,1	1,1
Normalized											
	2010	Referência REN	20-20-20 REN	A	B	C	D	E	F	Average	Std. Dev.
SRP	34%	46%	54%	52%	57%	53%	45%	49%	50%	51%	4,1%
Coal	13%	15%	15%	10%	10%	10%	12%	10%	15%	11%	2,1%
Natural Gas	20%	21%	12%	10%	10%	17%	21%	17%	16%	15%	4,5%
LargeHydro	28%	18%	19%	24%	19%	19%	21%	21%	18%	20%	2,1%
Import	5%			5%	5%	2%	2%	3%	1%	3%	1,7%

SRP in TWh										
	2010	A	B	C	D	E	F	Average	stddev	
Renew. Cogen.	1,7	2,8	6,3	5,5	3,0	3,1	5,0	4,3	1,5	
Non-Ren. Cogen.	4,5	5,5	7,0	10,0	10,5	5,6	4,5	7,2	2,5	
Wind	8,9	20,0	18,0	20,0	17,6	12,9	20,0	18,1	2,8	
Hydro SRP	1,4	2,0	5,0	4,3	3,0	4,5	4,0	3,8	1,1	
RSU	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,5	0,0	
Biomass	0,6	2,0	4,0	1,2	0,9	3,0	2,5	2,3	1,2	
Biogas	0,1	0,1	0,1	0,1	0,1	0,3	0,1	0,1	0,1	
Photovoltaics	0,2	0,2	0,5	0,4	0,5	2,5	3,0	1,2	1,2	
Solar Thermal	0,0	0,0	0,5	0,4	0,0	0,0	0,5	0,0	0,3	

Normalized SRP										
	2010	A	B	C	D	E	F	Average	stddev	
Renew. Cogen.	10%	8%	15%	13%	8%	10%	13%	11%	2,7%	
Non-Ren. Cogen.	25%	17%	17%	24%	29%	17%	11%	19%	6,3%	
Wind	50%	60%	43%	47%	49%	40%	50%	48%	7,1%	
Hydro SRP	8%	6%	12%	10%	8%	14%	10%	10%	2,8%	
RSU	3%	1%	1%	1%	1%	1%	1%	1%	0,1%	
Biomass	3%	6%	10%	3%	2%	9%	6%	6%	3,0%	
Biogas	1%	0%	0%	0%	0%	1%	0%	0%	0,2%	
Photovoltaics	1%	1%	1%	1%	1%	8%	8%	3%	3,4%	
Solar Thermal	0%	0%	1%	1%	0%	0%	1%	1%	0,6%	

Social Optimal (TWh)										
	2010	A	B	C	D	E	F	Average	stddev	
Coal	6,9	7,0	0,0	4,0	0,0	7,0	8,8	4,5	3,8	
Natural Gas	10,4	7,0	4,0	4,0	23,0	10,5	14,1	10,4	7,3	
LargeHydro	14,3	21,0	20,2	20,0	26,9	17,5	26,5	22,0	3,8	
Renew. Cogen.	1,7	2,9	10,5	4,0	2,0	3,2	5,3	4,6	3,1	
OtherCogen.	4,5	5,8	8,4	10,0	5,3	5,7	4,7	6,7	2,1	
Wind	8,9	15,8	24,2	19,0	13,7	12,3	17,9	17,1	4,2	
SRP Hydro	1,4	2,6	6,3	4,3	2,0	4,6	4,1	4,0	1,5	
RSU	0,5	0,5	0,5	0,5	0,4	0,5	0,5	0,5	0,0	
Biomass	0,6	4,2	5,7	4,3	2,9	3,8	2,6	3,9	1,1	
Biogas	0,1	1,1	0,1	2,0	0,1	0,4	0,1	0,6	0,8	
Photovoltaics	0,2	2,1	0,5	4,0	0,5	4,0	3,2	2,4	1,6	
Solar Thermal	0,0	0,0	0,5	4,0	0,0	0,4	0,5	0,9	1,5	
Import	2,6	-3,3	-3,9	0,0	1,6	-1,7	-4,2	-1,9	2,3	

Social Optimal (Normalized)										
	2010	A	B	C	D	E	F	Average	stddev	
Coal	13%	11%	0%	5%	0%	11%	11%	6,3%	5,4%	
Natural Gas	20%	11%	5%	5%	29%	15%	17%	13,7%	9,1%	
LargeHydro	28%	32%	26%	25%	34%	26%	32%	29,0%	3,9%	
Renew. Cogen.	3%	4%	14%	5%	3%	5%	6%	6,1%	3,9%	
OtherCogen.	9%	9%	11%	13%	7%	8%	6%	8,8%	2,6%	
Wind	17%	24%	31%	24%	18%	18%	21%	22,6%	5,1%	
SRP Hydro	3%	4%	8%	5%	3%	7%	5%	5,3%	2,0%	
RSU	1%	1%	1%	1%	1%	1%	1%	0,6%	0,1%	
Biomass	1%	6%	7%	5%	4%	6%	3%	5,3%	1,6%	
Biogas	0%	2%	0%	3%	0%	1%	0%	0,8%	1,0%	
Photovoltaics	0%	3%	1%	5%	1%	6%	4%	3,2%	2,2%	
Solar Thermal	0%	0%	1%	5%	0%	1%	1%	1,1%	1,9%	
Import	5%	-5%	-5%	0%	2%	-3%	-5%	-2,6%	3,0%	

SOCIAL IMPACT ON PROJECT ASSESSMENT: AN INTEGRATED METHODOLOGY FOR THE ASSESSMENT OF INVESTMENT PROJECTS IN RESEARCH AND DEVELOPMENT (R&D) AT A SOCIETY LEVEL

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KEYWORDS

R&D investment, social benefit, survey analysis

ABSTRACT

Nowadays, organisations increasingly need to adapt to the fast evolution of markets and societies in our globalised world in order to be competitive. Therefore, it is essential to take the right decisions when it comes to invest in R&D&i projects.

The present research focuses not only on the analysis of how R&D&i projects are assessed and selected but also on new proposals to improve them, with the aim of obtaining a suitable methodology which contributes to improve the competitive advantage and to integrate criteria of social nature both in organisations and in the Public Administration. The methodology which has been used in this research includes both interviews and analysis of the data obtained through them.

INTRODUCTION

As all R&D activities begin with an idea, the most important decisions all companies have to make are those related to financing and developing new ideas and projects as well as those linked to determining whether existing projects should be set aside or continued (Henig and Katz, 1996).

Investment in R&D is an essential element if we are to increase competitiveness, especially in the case of technology-based companies (Bitman and Sharif, 2008). But when funds are limited and there are several alternative projects, it is necessary to define a methodology that enables us to balance the different aspects that must be taken into consideration in the decision-making process. In other words, the choice of investment projects is an important strategic decision for all businesses. Several studies have revealed that the use of traditional financial techniques for project-assessment purposes is not the most suitable one when it comes to analysing investment in R&D (Chan et al., 2001). The use of these techniques consists, essentially, of the estimate of the investment's cash flows and of the

application of methods to assess their viability (e.g. NPV and IRR). This procedure involves that the costs and benefits associated with investment are easily and objectively quantified and this cannot always be achieved. Particularly, in the case of R&D projects, three different types of benefits can be distinguished: strategic, measurable and intangible. For instance, if we take the example of intangible benefits, it should be noted that they are difficult to quantify but may nevertheless have a significant impact on ROI (Adler, 2000).

As emphasized by Henig and Katz (1996), the NPV of a project in basic research is virtually impossible to calculate. Companies are looking for new technologies, yet to be developed, where it is impossible to extrapolate probabilities from past experiences. Companies must make all their assessments while minimizing any information leaks to their competitors.

On the other hand, there is a noticeable need for companies to include in their decision-making process specific criteria of non-financial nature (e.g. strategy, flexibility, quality, social returns). In fact, these non-financial aspects are particularly important in the new industrial environment in which firms operate, where new technological developments tend to occur more rapidly than the evolution of project-evaluation techniques (Brownell and Merchant, 1990).

In recent decades, increasing competition, reduced life cycles and globalisation of markets have highlighted the interest of measuring the importance of research and development (R&D). This issue has indeed become a major concern for R&D managers (Chiesa et al., 2009).

The different contributions from the study of the technological and evolutionary aspects of the economy question the need to incorporate social criteria in the field of scientific research and engineering. These contributions allow us to establish a new concept of technological change based on the co-evolution of technology and society (Rip and Kemp, 1998).

The empirical study focused on how R&D investment projects are evaluated in the wood and furniture sector. The methodology which has been used in this research

includes both interviews and analysis of the data obtained through them.

Through this survey, attention has been given to different points of view on the chosen topic. In order to achieve this, not only companies of the above-mentioned sector, but also technology centres, the University of Vigo and trade unions, as well as an agent of programs of R&D, were interviewed, with the aim of providing a wider view of the selected subject.

LITERATURE REVIEW

In this section, a number of studies on the importance of investing in R&D and the selection and evaluation of projects were reviewed, emphasising the role of non-financial criteria in the evaluation process.

Investment in R&D is an essential element for increasing competitiveness, especially in technology-based companies (Bitman and Sharif, 2008). These authors stressed the importance of not only adopting a financial perspective but also a qualitative perspective with an appropriate model.

In other words, it is necessary to find a suitable methodology which takes into account a range of different criteria that are to be considered when selecting which projects should be developed (Henig and Katz, 1996).

The process of making the right decisions when it comes to investment should be properly modelled (Zopounidis and Doumpos, 2002). According to these authors, it is advisable to adopt multi-criteria methods which take into account a range of quantitative and qualitative factors when assessing projects. Several studies have shown that the use of traditional financial techniques in project evaluation was not the most suitable for the analysis of investment in R&D (Chan et al., 2001). Therefore, it is necessary to include various approaches (strategic, analytical and financial).

This is important for our study because it is intended to include the social focus. Chiesa et al. (2009) examine the problematic task of assessing R&D results. In particular, these authors explore the iteration between measurement objectives, dimensions of performance and contextual factors in the design of a performance measurement system for R&D.

In conclusion, it is essential to invest in R&D and to make a proper assessment of projects based on multiple criteria, due to the competitive environment in which companies coexist. Therefore, the inclusion of social criteria for evaluation of R&D investment projects is highlighted in this study. Afterwards, we will present some theories that deal with this issue.

SOCIAL APPROACH

The different contributions from the study of technology are concerned with the need to incorporate social criteria in the field of scientific research and engineering. These contributions allow us to establish a new concept of technological change based on the co-

evolution of technology and society (Rip and Kemp, 1998).

The concept of social responsibility arises in the twentieth century. Although the term comes from the 50s-60s in the U.S., it failed to develop in Europe until the 90s, when the European Commission used this concept to involve employers in an employment strategy that would generate greater social cohesion. In the European society there were increasing problems related to long-term unemployment and the resultant social exclusion.

Over time social responsibility is gaining importance and companies are trying to find a proper balance between economic profitability and social responsibility.

In order to find out what the major policies, strategies and practices that are being developed regarding corporate social responsibility (CSR) and how to evaluate them, Galician companies created the Permanent Observatory for CSR in 2010.

The growing interest in CSR has led to the establishment of new awards and recognitions, the proposed measurement indicators, the study of the perceptions of different stakeholders (managers, shareholders, employees, customers, etc.) or the inclusion of social and environmental criteria in awarding public contracts, which means that CSR is not a fad, but a new way of understanding the role of business in our society while obtaining financial, social and environmental benefits and improving the competitiveness of the company.

These criteria include social impact on R&D management. This impact begins to be seen as a potential source of profit, as it increases the degree of consumer confidence and reduces the likelihood of conflicts among the different groups affected (Carroll and Buchholtz, 2009).

In some R&D programmes designed to fund research we can find references to social aspects, for instance in Framework Programme n° 7.

From a standpoint that gives priority to social criteria rather than to economic effects, it is necessary to carry out a sector analysis and the identification of measures and actions which may enable us to determine whether social return on investment in R&D (RESIPIDI) exists. According to Ares et al. (2008), such factors can be considered to be either positive or negative effects of public investment in R&D.

Governments are trying to take more into account social progress. For instance, integration of women and disabled people in the workplace is becoming an important issue in our days. This should be taken into consideration by companies when assessing R&D projects.

The concept of social impact can be broadly defined as a combination of multiple environmental, socioeconomic and scientific factors which are often left out of traditional mechanisms for evaluating R&D (Moñux, et al, 2006).

It is necessary to analyse, discuss and synthesise to solve social problems, just in the same way as medical examinations are performed to measure health indicators and to make sure that our organs and senses work properly.

Before investing in R&D projects, companies should decide how to finance them. Funds can be both private and public. Some relevant aspects of public finance will be discussed here.

We have focused on the Galician Plan R&D& i INCITE. The main objective of this plan is to develop the research and innovative Galician potential in order to achieve positive results in social welfare and economy. To this end, the Plan should look up to the future and be based on social trends to anticipate any potential social changes that might occur. Figure 1 illustrates that the Galician innovative system consists of four agents:

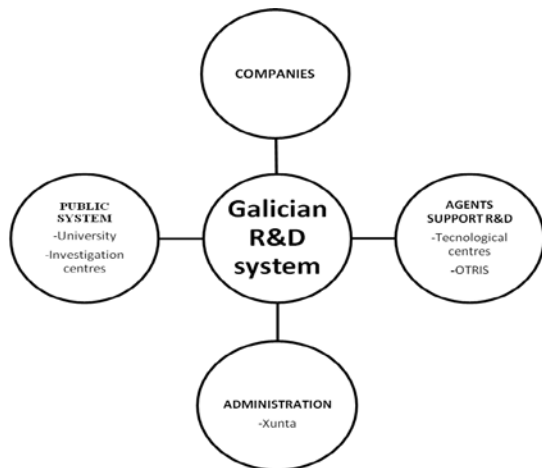


Figure1: Galician R&D system

RESEARCH METHODOLOGY

In this section the research methodology adopted in this study is described. Such methodology was based on interviews.

We defend the methodological complementarity by means of an appropriate adjustment of the different existing approaches in order to achieve a better research in which the objectives of the research themselves will be essential when deciding which method to use. Its contribution to this project is a special role assigned to qualitative research techniques. This role is applied to a large number of questions in such a way that the opinions of those interviewed are those which are the first to be considered and then lead to further reflection (Olaz 2008, 2007). On the other hand, one of the sections deals with quantitative techniques by means of an interview, which is an essential element when selecting those common criteria which are considered relevant by respondents. That is why the methodology

we have adopted is of mixed nature and is focused on the case study.

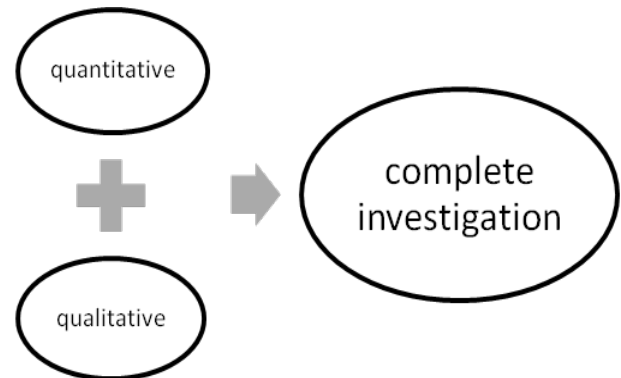


Figure 2: Methodology

Our methodology includes the selection of a few interviews which consist of both open-ended questions and closed questions.

In order to carry out this research project we chose to conduct two-part interviews: on the first hand, we can find essential questions whose aim is to deepen on the subject and which are of great interest to the interviewer, who can add more questions during the interview if appropriate. On the other hand, we have used a standard questionnaire which enables us to compare the answers provided by different respondents and to quantify the results we have obtained. We have opted for this kind of interviews because we find it is the most flexible means in terms of data and that with a highest response rate, as the interviewee agrees more and more to be controlled by the interviewer, despite the fact that it is obviously a laborious methodology which demands much time.

We have opted for individual interviews in most cases. Interviewees were always representatives of the companies or institutions most involved with R&D funding. In one case there was a group interview in which several people were involved in the organization. The first questions were closed, as we had designed them to provide the interview with a context. Nevertheless, some room for open questions was always given to interviewees so that they could express their opinions freely, what enabled us to compile extra information and views which were extremely useful for our research.

After completing the interviews, there was a stage of information processing and speech coding. Recorded conversations were transcribed to paper, a laborious but very interesting task which would permit us to analyse the information clearly and to focus on interpreting data.

We will now proceed to explain the three-part structure of the interview we used in our study. The heading explains that the purpose of the interview is to conduct a study on the evaluation of R&D in Galicia, even though we had previously explained this to the interviewees in

previous encounters. It states the duration of the interview (30 minutes) and also that the information provided will be only used for research purposes. The first part of the interview consists in collecting general data of the company in question.

- Name of the company or institution;
- Market sector, field of activity;
- Contact person and his/her position in the company;
- Year in which the company was founded;
- Turnover;
- Number of employees;
- Position in the value chain: extractive, manufacturer, wholesaler, retailer, services;
- Attributes: exporter, high performance, certified quality, audited, other.

The second part is directly related to R&D projects evaluation. Questions 1-9 deal with R&D performed by the company to learn about its situation with regard to R&D+ i: number of years they have been developing projects, collaborators, employees involved, budget, previous projects, objectives, indicators and source of funding.

Questions 10-18 are more focused on public funding, R&D plans and project-monitoring. These questions enable us to find out the views companies have concerning their current plans on project assessment, by emphasizing social issues.

Finally, the third section of the interview consists of an optional questionnaire aimed at quantitatively assessing the current indicators drawn from the latest calls for R&D proposals for grants by the Galician Government (Xunta de Galicia) and the Spanish Ministry. We decided to combine technological, social and economic standards because of their current rating and also in order to avoid monotony, but the main aim is to find out the main social criteria which are taken into account by companies when it comes to R&D projects. This questionnaire has been divided into two parts. In both cases a subjective numerical scale or Likert scale (1-5 points) has been used as appropriate to help us reach the two objectives pursued by this research.

- In the first section, we have tried to find out the assessment of current project evaluation made by those respondents who were familiar with or heavily involved in R&D funding and therefore knew the current criteria used for evaluation. In other words, our aim is to draw conclusions on whether R&D project assessment is being carried out in a satisfactory manner concerning the most recent calls which attracted the interest of the companies whose representatives collaborated with us. In the case of the companies we interviewed, most of them resort to private funding so they decided to ignore this part of the interview due to their poor knowledge of the applicable criteria.
- As for the second section, it has been designed to find out the score that the respondent would give to the different criteria to be applied when assessing R & D. This data enables us to draw conclusions regarding the criteria which are considered to be the most important parameters from all the points of view we have studied: business, research institutes, universities and unions. All respondents were in the position to complete this section of the interview as, although companies currently receive no public funding, they might wish to resort to it in the future. Therefore, all opinions were considered to be valid.

In order to select these indicators of the interview, we proceeded as follows:

- Read the latest announcements from Xunta de Galicia's programme SUMA (INCITE) - since they are the most attractive ones for many companies - so as to choose those criteria currently valued;
- Read the latest announcements from the National Plan in order to choose those criteria which are currently being evaluated;
- Review of the criteria used by RESIPIDI (Ares et al 2008);
- Review of the criteria suggested by previous studies (Alvarez, 2009; and Carvalho 2009);
- Review of the bibliography discussed in the study.

In all cases we selected the criteria which, in our opinion, would be more suitable for our study. It follows that in the sector programmes of the Xunta's INCITE Programme, social criteria are not given much importance since the current figure is lower than 5% at a regional level and only the presence of women is considered to be a social criterion.

RESULTS

As we are dealing with R&D project assessment, we first visited AENOR (the Spanish Association for Standardization and Certification) website in order to look for certified companies in R&D Management, since they would be more likely to know the subject of research and could possibly collaborate with us. As a consequence, a company of the wood sector –and, more specifically, devoted to furniture manufacturing– was selected for our research. Moreover, we contacted the Wood Technology Centre (CIS-Madera) which is located in Ourense (Galicia). At first, the idea was to study the points of view of a company and a technology centre.

After the interviews, we processed both the data and the conclusions drawn. As the information was too scarce to draw conclusions, we decided to try to contact other companies of the same sector as well as more technology centres. Moreover, we had the opportunity of interviewing a person who was linked to R&D funding at the University of Vigo, which was extremely interesting.

Since trade unions are organizations formed by workers for the defence and promotion of their social, economic and professional interests, we found it would be suitable to contact the major trade unions in Galicia for a possible collaboration.

Thus, this research enables us to compare five different views on the subject: business, technology centres, university, unions and project managers themselves. This will allow us to reach a wider perspective of the subject than our initial proposal. In total, our collaborators were three companies of the furniture sector, two technology centres, OTRI (University of Vigo), three trade unions and INCITE (the program manager of the Xunta de Galicia).

Before conducting the interviews, information was gathered with regard to R&D in the chosen sector. Afterwards, we will discuss the highlights of all the interviews we conducted by dividing the different opinions into groups.

With regard to companies, this survey has proved that there are different criteria for project selection, although not many of them are socially-based. Instead, companies are becoming more and more aware of environmental issues. On the other hand, we have found out that some firms seem to be more interested in having into consideration social issues when it comes to assessing projects. Therefore the present research has been useful for creating social conscience.

Prime factors like the search for products and services aimed at covering unsatisfied needs, staff development, contribution to environmental improvement, employment of women on R&D, social responsibility and the creation and maintenance of employment are some of the most valued criteria to measure the social impact.

Technology centres are those that prove to be less keen on the inclusion of social criteria when assessing projects. They rather seem to be more interested in having into account scientific and economical criteria such as the multiplier effect of investment, which will indirectly imply other social criteria like employment.

Regarding the University, it criticises the fact that well-established projects are not assessed by the administration, an opinion which is shared by the manager of the programme INCITE, who collaborated with us on this research. This might be helpful to assess both the current R&D plan and its benefits and also to verify if appropriate procedures are being carried out when it comes to financing. Attention should also be given to the difficulty experienced by some associations which develop R&D projects (e.g. associations of disabled people) when trying to obtain public financing. Trade unions have mainly contributed by sharing with us their view on the current Galician R&D plan and its need for change, going for public financing in order to enable R&D to work by taking into consideration social criteria.

The most valued criteria to measure the social impact by trade unions are contribution to solving social problems (unemployment) and the creation and maintenance of employment.

CONCLUSIONS AND FURTHER RESEARCH

From this empirical study, it can be concluded that even if the interest in the scientific level is remarkable (it should be noted that we are referring to R&D projects) social repercussion criteria are also taken into account. Prime factors like the creation and maintenance of employment and the search for products and services aimed at covering unsatisfied needs are some of the most valued criteria to measure the social impact.

We think that it is advisable to continue through several stages, such as carrying out the appropriate tasks which will enable the public administration to incorporate social criteria, when assessing applications for R&D grants, so as to represent about 20% of all the criteria to be taken into account. This would mean an increase of 15%, since the current figure is lower than 5% at a regional level and only the presence of women is considered to be a social criterion.

Should public administration take into account social criteria in its announcements of grants, companies and institutions would also begin to consider those when selecting the projects in which they wish to invest.

In short, social benefits would be strengthened by adopting such measures.

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MICRO ENTERPRISE INDIVIDUAL PROGRAM THE FACTORS DETERMINING TO ACCESSION: AN EMPIRICAL STUDY IN THE VALLEY OF SAN FRANCISCO	
João Nascimento,* Ana Santos, Adriana Silva, Juliana Reis and Francisco Duarte	35
THE NEED FOR A NEW SUSTAINABLE ECONOMIC MODEL	
Humberto Rito Ribeiro	45
SUSTAINABLE BUSINESS MODELS FOR WEB 3.0	
Leonor Gaudêncio,* Fernando Almeida and José Oliveira	53
PROJECT PORTFOLIO SELECTION AND MONITORING – A CASE STUDY	
António Amaral* and Madalena Araújo	59
TECHNOLOGICAL EXTENSION PROGRAM PILOT PROJECT IMPLEMENTED IN THE CAPITAL GOODS SECTOR IN SÃO PAULO - BRAZIL: PROMOTING TECHNOLOGICAL INNOVATION	
Dorotéa Bueno,* Fernando Romero and Filipa Vieira	69
TECHNOLOGY EVALUATION AND LICENSING: A LITERATURE REVIEW AND AN ASSESSMENT OF THE PORTUGUESE UNIVERSITIES TECHNOLOGY TRANSFER PRACTICES	
António Rocha and Fernando Romero	77
ON THE MULTI-MODE, MULTI-SKILL RESOURCE CONSTRAINED PROJECT SCHEDULING PROBLEM – COMPUTATIONAL RESULTS	
Mónica A. Santos* and Anabela P. Tereso	93
ADDRESSING SUSTAINABILITY: COMPREHENSIVE FRAMEWORKS FOR EVALUATING NEW PRODUCT DEVELOPMENT	
Shantesh Hede,* Manuel Nunes, Paula Ferreira and Luis Alexandre Rocha	101
INTER-FIRM COST MANAGEMENT IN HIGH-TECH PRODUCT DEVELOPMENT PROJECTS IN THE PLASTICS PROCESSING INDUSTRY	
Carlos Barbosa, Paulo Afonso,* Manuel Nunes and Marta Gomes	107
COST ANALYSIS FOR THE ECONOMIC EVALUATION OF HEALTH CARE SERVICES	
Carla Duarte and Paulo Afonso*	117
AN ACTIVITY-BASED COSTING MODEL FOR STRATEGIC DECISIONS IN TRANSPORTATION ON DEMAND PROJECTS	
Joaquim Vitor Oliveira,* Paulo Afonso and José Telhada	127

STRATEGY FOR ELECTRICITY SUPPLY OF STEEL AND MINING SECTOR FIRMS	
Armindo Bredariol Junior,* André Leite and Nivalde José de Castro	135
THE ROLE OF ENERGY PLANNING IN NEW HYDROPOWER INVESTMENTS	
Nivalde José de Castro, Guilherme de A. Dantas* and Raul R. Timponi	141
OPTIMIZATION MODELS TO SUPPORT SUSTAINABLE ELECTRICITY PLANNING DECISIONS	
Sérgio Pereira,* Paula Ferreira and A. Ismael F. Vaz	149
POLICY AND LEGISLATION FOR A NEW ENERGY PARADIGM: THE CASE OF THE PORTUGUESE LEGAL FRAMEWORK FOR MICROGENERATION	
José Gonçalves,* Paula Ferreira and Paulo Afonso	157
DECISION-MAKING PROCESS IN INVESTMENT PROJECTS	
Nuno Moutinho	165
PROJECT FINANCING AND VERTICALIZATION IN INFRASTRUCTURE PROJECT EVALUATION: A CASE STUDY OF ABENGOA	
Luiz Ozorio,* Roberto Brandão and Nivalde Castro	173
REAL OPTIONS THEORY IN COMPARISON TO OTHER PROJECT EVALUATION TECHNIQUES	
Bartolomeu Fernandes,* Jorge Cunha and Paula Ferreira	187
EVIDENCE ON THE INVESTMENT-CASH FLOW SENSITIVITY FOR A PANEL OF PORTUGUESE MANUFACTURING FIRMS	
Jorge Cunha* and António Paisana	195
WHICH PROJECT CHARACTERISTICS ARE IMPORTANT? WHAT ARE THE PROJECT SUCCESS FACTORS?	
Nuno Moutinho* and Helena Mouta	205
THE COST/BENEFIT ANALYSIS IN THE SCOPE OF NEOCLASSICAL ECONOMICS	
Humberto Rito Ribeiro,* José Manuel Pereira and Edson Luiz Riccio	223
THE EVALUATION OF BIOMASS POWER PROJECTS	
Patrícia Carneiro* and Paula Ferreira	231
A COST-BENEFIT ANALYSIS OF AN INTELLIGENCE AND DEMAND- RESPONSIVE PUBLIC TRANSPORT SYSTEM FOR ELDERLY AND DISABLED	
Vítor Oliveira,* José Telhada and Paula Ferreira	235

**DEVELOPMENT OF A COST-BENEFIT MODEL
FOR MICRO CHP SYSTEMS**

Ana C.M. Ferreira, * Luís A. S. B. Martins, Manuel L. Nunes and Senhorinha F.C.F. Teixeira 243

COST-BENEFIT ANALYSIS IN OCCUPATIONAL HEALTH AND SAFETY

Delfina Ramos, * Paulo Afonso and Pedro Arezes 251

**SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT - THEORETICAL
CONTRIBUTIONS**

Nuno Moutinho * and Helena Mouta 259

**ECONOMIC EVALUATION OF A DEMAND RESPONSIVE TRANSPORT IN
RURAL AREA**

Ana Dias, * José Telhada and Maria do Sameiro Carvalho 269

ON THE SOCIAL RETURN OF R&D PROJECTS AND SUPPORT PROGRAMMES

Olalla Barreiro, * Paula Ferreira and Enrique Ares 279

**USING EXPERT INTERVIEWS TO CREATE ELECTRICITY SCENARIOS AND
TO ASSESS SOCIAL IMPACTS**

Fernando Ribeiro *, Paula Ferreira and Madalena Araújo 285

**SOCIAL IMPACT ON PROJECT ASSESSMENT: AN INTEGRATED
METHODOLOGY FOR THE ASSESSMENT OF INVESTMENT PROJECTS IN
RESEARCH AND DEVELOPMENT (R&D) AT A SOCIETY LEVEL**

Ana Fernández Fernández, Jorge Cunha * and Enrique Ares Gómez 293

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