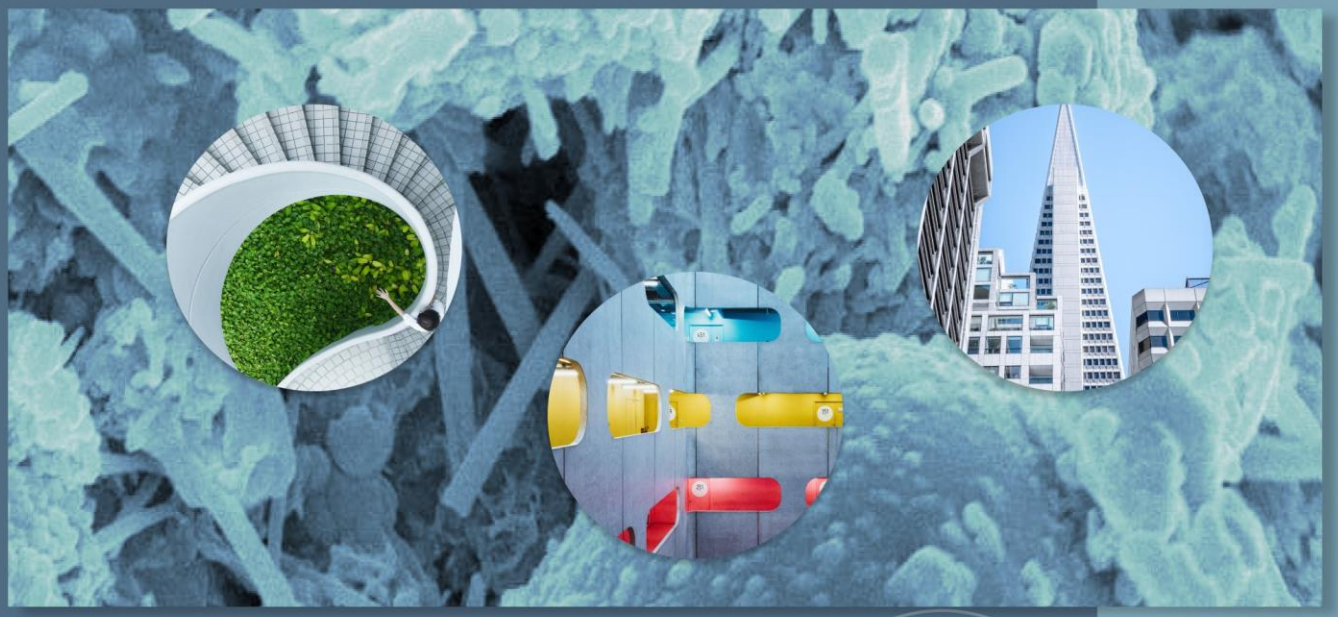

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Índice

Methodologies for estimating the built environment stock: an overview

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Keywords: Built Capital Stock; Construction Sector; Construction Investment; National Accounts; Perpetual Inventory Method.

Abstract. The role of the construction sector in the process of economic growth and development is well recognized in the literature. However, in the most advanced industrial economies, as well as emerging economies, the construction industry is no longer focused on providing a single service, i.e., a building or physical infrastructure, but on a variety of services and improvement of human and natural environments. Built capital stock is a major component of any country's produced fixed capital as designated in the System of National Accounts (SNA) of the United Nations. According to several writers, the knowledge of reliable data of building and other construction assets of a specific country or region is a crucial element for the long-term management of these assets. This paper presents an overview of the Perpetual Inventory Method (PIM) used for estimating capital stock and some methodologic issues regarding the measures of construction investment and of built capital stock. Additionally, based on the results of an earlier work, estimates of the Cape Verde's built capital stock for the year 2014 are presented. The level of the of the built capital stock of a specific country and its impact on the development pattern of the construction industry is a suggestion for further studies.

Introduction

Built capital stock is a major component of any country's produced fixed capital assets as designated in the System of National Accounts (SNA) of the United Nations (United Nations, 2008a). Building and other construction assets constitute a significant part of a country's physical and economic infrastructure. The construction industry (indeed, building and infrastructure development) plays a key role into production and wealth generation. The economic impact can be transformative, especially at lower levels of income per capita (OECD, 2013). As pointed out by Maddison (1987, 2006), the close association between physical capital and different measures of national economy is one of the reasons why physical infrastructure has been considered a powerful engine of economic growth and development. However, in the most advanced industrial economies, as well as emerging economies, the construction industry is no longer focused on providing a single service, i.e., a building or physical infrastructure, but on a variety of services and improvement of human and natural environments (Carassus et al, 2006). The pursuit of sustainable development should accommodate a balance between physical capital, natural capital, and human capital, depending on the circumstances of the country.

Thus, another approach for assessing the performance of an economy besides the measurement of its national output in a given period is accounting for its capital wealth. This approach stresses the importance of preserving a portfolio of capital assets to ensure that an economy's productive base can be maintained (Ruddock et al, 2019). The production of new buildings and other structures in any given period adds to a nation's economic wealth, in the form of the built environment contributing to and complementing its productive and social capital.

Within the context of national accounting, there are two types of physical capital measures, each reflecting a different role of physical capital. The first type of measure looks at capital in its function as a provider of services in production. The second type of capital measure captures its role as a store of wealth. Its aggregate is the net capital stock (also known as wealth stock) that captures

the market value of capital goods. Most modern works, both at national and international levels, that publish capital stock statistics (for instance, Luiss Lab of European Economics, 2021; Inklaar and Timmer, 2015; Derbyshire et al., 2013) are based on the Perpetual Inventory Method (PIM) outlined in the two editions of the OECD Manual- Measuring Capital (OECD, 2001, 2009).

The remaining of the paper is structured as follows: the next section presents the main databases that provides fixed capital statistics and discusses the measures of construction investment and built capita stock; the third section presents an overview of the PIM methodology for estimating capital stock; the fourth section presents the estimates of the built capital stock in Cape Verde. Most of the results and analyses presented in this section are drawn from an earlier work (Lopes et al, 2019) and; a concluding remark finalises the analysis presented in the study.

Data sources and measures of construction investment and built capital stock

Investment in building and other construction structures is a component of gross fixed capital formation (GFCF) as described in the SNA of the United Nations. According to the SNA 2008, GFCF consists of the purchase of goods (and services) that are used in production for more than one year. This publication classifies capital stock statistics according to: type of assets; institutional sectors; and economic sectors as described in the International Standard Classification of Economic Activities (ISIC revision 4) (United Nations, 2008b). The SNA of the United Nations identifies five institutional sectors: households; non-financial corporations; financial corporations; non-profit institutions serving households (NPISH) and; general government. In terms of type of assets, the built capital stock is comprised of: dwellings; and other buildings and structures (including land improvements). It is worth noting that and major improvement to dwellings and other building and structures are also accounted for as built assets. Other fixed assets which are recognised in both the European System of Accounts (ESA, 2010) and SNA 2008 are: machinery and equipment and weapon systems; cultivate biological resources and; intellectual property products (Table 1). Capital stock of an economy is the accumulation through time of these assets. This indicator can be expressed as gross capital stock (which does not take depreciation of assets into account) or net capital stock (which takes depreciation into account), which is part of an economy's balance sheet in the context of income and wealth accounting.

The two most important databases that provide capital statistics are The Pen World Tables (PWT) (Inklaar and Timmer, 2015) and EUKLEMS & INTANProd (Luiss Lab of European Economics, 2021).

The PWT version 10.0 is a database with information on relative levels of income, output, input and productivity, covering 183 countries between 1950 and 2019. The 'Main' file provides data on the expenditure-side gross domestic Product (GDP) at current and chain -linked purchasing power parities (PPPs), output-side GDP at current and chain-linked PPPs, and total net capital stock at current and chain-linked PPPs. These data are presented in million 2017 US$. The national account-based variables provide real GDP at constant 2017 national prices (in million 2017US$) and total net capital stock at constant 2017 national prices (in million 2017US$). The Capital file of the data base provides net capital stock statistics disaggregated in the following components: current-cost net capital stock of residential and non-residential structures; current-cost net capital stock of machinery and (non-transport) equipment; Current-cost net capital stock of transport equipment and; current-cost net capital stock of other assets. The figures are presented in national currencies.

The EUKLEMS database provides harmonised, industry-level data on production, value added, inputs, labour, investment and capital stocks across EU, USA and other high-income economies. The capital file provides data on GFCF and net capital stock in the following format: computing equipment; communication equipment; computer software; transport equipment; other machinery and equipment; residential structures; non-residential structures; cultivated assets; research and development, other IPP assets and; all assets. The data are presented in current prices, previous year prices and in volume 2015 reference prices, both measured in millions of national currencies.

Table 1: List of asset types

Total Fixed assets
…….Total Construction
……Dwellings
……Other buildings and structures
……Machinery and equipment and weapon systems
……Transport equipment
……ICT equipment
……Computer hardware
……Telecommunications equipment
……Other Machinery and equipment and weapon systems
……Cultivate biological resources
…….Intellectual property products (IPP)
……Research and development
……Computer software and databases
……Other IPP

Source: United Nations (2008-a)

An overview of the PIM methodology for estimating capital stock

Most works that attempt to estimate capital stock employs some variant of the Perpetual Inventory Method (PIM). As stated before, most recent works and international organisations that produce databases on capital statistics (Berlemann and Wessrlhoft, 2014; Derbyshire et al., 2013, Inklaar and Timmer, 2015; Luiss Lab of European Economics, 2021) employ the PIM methodology outlined in in the two editions of the OECD Manual- Measuring Capital (OECD, 2001, 2009). The PIM, as implied by its name, interprets a country's fixed capital stock as an inventory (Berlemann and Wessrlhoft, 2014). The PIM methodology involves accumulating past gross fixed capital formation and deducting the value of assets that have reached the end of their service lives. Both capital formation and discards of assets are revalued either to the prices of the current year (current prices) or to the prices of a single year (constant prices).To estimate the total capital stock, the following data and assumptions, broken down by type of asset, are required (OECD, 2013): i) a sufficiently long time series of data on fixed investment; ii) a sufficiently long time series of price indices (deflators); iii) information on initial capital stock at the time when the tomes series of investment start; iv) assumptions regarding the average service lives and the retirement function of the relevant assets and; v) assumptions regarding the depreciation function of the relevant assets.

One critical aspect of this methodology is the setting up of the depreciation method to account for the writing-off of consumed fixed capital. In the straight-line depreciation method, the consumption of fixed capital is linear in nature as can be seen in Equation (3) below. The corresponding mortality function is the "simultaneous exit", i.e., an asset is removed from the capital stock when its value has depreciated to zero in the final year of its service life (OECD, 2009). These assumptions are adopted by the Singapore Department of Statistics and, according to Maddison (1992, cited in Derbyshire et al., 2013), represent a useful approximation of reality when calculating the capital stock. However, OECD (2009) suggests that simultaneous exit is not a realistic retirement pattern and suggests that other retirement patterns that assume a certain bell-shaped function around the average age of retirement are more realistic.

The application of the PIM methodology involves the following steps (Derbyshire et al., 2013):

- The calculation of the gross capital stock:

$$CS_t = \sum_{i=0}^{d-1} I_{t-1} \quad (1)$$

Where CS_t is the capital stock in an asset in year *t;*
I_t is investment in year *t;*
d is the assumed service life of the asset

This values the gross capital stock at its historical (or acquisition) costs. The goal of the PIM, however, is to arrive at a valuation in prices of the year for which the value of the stocks is calculated;

- The revaluation of the capital to prices in year *t* from the value of the capital stock at its historical cost:

$$CS_{t,t} = \sum_{i=0}^{d-1} I_{t-i} * P_{t-i,t} \quad (2)$$

Where $CS_{t,t}$ is the capital stock in an asset in year t, in prices of year *t;*
$P_{t-i,t}$ is the price in year *t-i,* with *t* the year t to which the capital stock is valued;

- The calculation of the net capital stock from the gross capital stock minus the accumulated consumption of fixed capital:

$$NCS_{t,t} = \sum_{i=0}^{d-1} \left(I_{t-i} * P_{t-i,t}\right) * \left(1 - \frac{i}{d}\right) \quad (3)$$

Where *d* is the assumed service life of the asset;
i is the current year the asset is at within its service life.

An approach of estimating the capital stock in the benchmark year, which is recommended by OECD (2009) is based on Harbeger (1978). This approach employs neoclassical growth theory and relies on the assumption that the economy under consideration is in its steady state (OECD, 2009). As a consequence of this assumption, output grows at the same rate as the capital stock, i.e:

$$K_{t-1} = {}^{I_t}/_{gI + \delta}$$

Where I_t is investment in the initial year;
δ is the depreciation rate (geometric depreciation) and;
gI is an estimate of the steady-state growth rate of investment in that asset, typically implemented as an average growth rate in the first years of the observation period.

Estimates of the built capital stock in Cape Verde

Data and assumptions. As discussed above the application of the PIM to estimate the Built Capital Stock require a set of assumptions and inputs: i) an initial bench-mark estimate of the country's built capital stock; ii) statistics on gross fixed capital formation in construction extending back to the bench-mark year; iii) asset price indices; iv) depreciation function to devalue the assets; and v) information on the average service lives of different construction assets and on the mortality function.

The depreciation method and mortality function referred to above are, respectively, the linear deprecation method and the simultaneous retirement pattern. With respect to average service lives, The OECD Manual (OECD, 2001; OECD; 2009) presents average services lives for different type of assets for a number of countries. For example, the average services lives used by the Singapore Department of Statistics are:

- Residential Buildings- 80 years
- Non-residential Buildings-40 years
- Other Construction and Works-40 years
- Ships and Boats- 20 years
- Aircraft -15 years
- Road Vehicles- 10 years
- Machinery and Equipment- 15 years

A study dealing with the capital stock in the NUTS 2 regions of the EU-28 (Derbyshire et al., 2013) adopted a service life of 68 years for housing construction, 50 years for civil engineering works and 38 years for 'other' assets.

The National Accounts of the Cape Verde's National Statistical Office presents data on gross fixed capital formation in construction that are consistent with the SNA of the United Nations. In the 'Old Series' of the National Accounts, construction investment data for the period 1980-2007 are disaggregated in the following format: residential housing; non-residential housing; civil engineering works and 'other' construction. The 'New Series' of the National Accounts presents data for the period 2008-2014 that are disaggregated by: private construction works; and public construction works. It was assumed, based on the 'Use and Supply Table' of the National Accounts, that civil engineering works and 'other' construction works for the period 2008-2014 represent 80% of the public construction works.

Thus, for reasons of consistency in the data throughout the period 1980-2014, these are disaggregated in the following type of assets: building construction; and civil engineering works and other construction. The assumed averaged service lives are the following:

- Building construction – 60 years
- Civil engineering and other construction works - 45 years.

In order to estimate the initial capital stock in the benchmark year (1980), the OECD Manual provides some recommendations for estimating the stock of structures under limited information. When the housing stock is used as input, a minimum of the information that is required is the following (OECD, 2009):

- the number of dwelling units at mid-year of the period under consideration (WD,t), which is usually available from the most recent census;
- an estimate of the long-term growth rate (b) of the number of dwellings;
- the average price level of period t of a newly constructed dwelling (of a particular category), excluding land (P0D,t), where the subscript 0 indicates the age of the asset which in the present case is new.
- an estimate of the expenditure on major improvements on dwellings and land during the present year (P0D,t Mt).

The 2010 Census of Population and Housing (INE-CV, 2011) provides some useful information for estimating the initial built capital stock, by using the OECD methodology. According to (INE-CV, 2011) the number of buildings in Cape Verde totalled 114,469 units in 2010. The rate of increase in the the number of buildings in the period 1975-1985 was 3.41% per year. This can be assumed as the long-run annual growth rate in the number of buildings. As there are no available data on major improvement in housing, it is assumed that the share of major improvement to total housing investment in 1980 was 0.1. The average service life is set up at 60 years and the depreciation rate is 0.02667 (geometric depreciation), as recommended by OECD (2009).

Results and discussions.

- Net Built Capital Stock in 2014

The net capital built capital stock for 2014 is the sum of the results of three aggregates: i) accumulation of the fixed capital formation, net of depreciation, in the period 1980-2007; accumulation of the fixed capital formation, net of depreciation, in the period 2008-2014; the initial net bench-mark stock, also net of depreciation. As stated above, the service lives for building construction and civil engineering works are, respectively, 60 and 45 years. The depreciation method is the straight–linear one.

-Period 1980-2007

Data on GFCF in construction for this period is available both in current prices and at 1980 constant prices. Thus, constant prices data are used for calculating net capital stock in construction according to equations 2 and 3. The figures are firstly rebased to 2007 prices by using a series of GFCF deflators (residential housing, non-residential housing and civil engineering works) and then revalued at 2014 prices by using the private GFCG and public GFCF's implicit chain-linked indices for, respectively, building construction and civil engineering works. For reasons of international comparability, the results are presented in Euros (1€ =110.265 CVE).

Net Capital Stock in Building Construction = €1,910,366,464;
Net Capital Stock in Civil Engineering Works = € 612,215,504;
Total Net Capital Stock in Construction= € 2,522,581.966.

-Period 2008-2014

Data on GFCF in construction for this period is available at both current prices and chained-linked prices at the 2007 reference year. Firstly, data at the 2007 prices are used for calculating the net capital stock in construction according to equations 2 and 3. The results are then revalued at 2014 prices by using the private GFCG and public GFCF's implicit chain-linked indices for, respectively, building construction and civil engineering works. Again, the figures are presented in Euros.

Net Capital Stock in Building Construction = €1,311,094,503;
Net Capital Stock in Civil Engineering Works = € 909,999,083;
Total Net Capital Stock in Construction= €2,221,093,586.

-Net Built Stock of the Base-year Stock (1980)

New housing investment in 1980 (It) = € 4,451,095 (1980 constant prices)
Average Service Life = 60 years
Rate of depreciation (r) = 0.02667
Long-run growth rate per year (b)= 0.0341
Share of major improvements (α/b) = 0.1
C= (1+ α/b) (1+/b) /(b+ r) = 18.12, which corresponds to the ratio of new investments to the net stock.
Net stock of dwelling at the base-year = It* C= € 80,653,860
The calculation of the net capital stock in 2014 is made is the same manner as that of the period 1980-2007

Net Capital Stock in Building Construction (2014) = €132,780,334.

- Ratio of Capital Stock to GDP

The value of the country's net built capital stock in 2014 was € 4,876,455,888. Net capital stock in building and construction represents 69% of and civil engineering and other construction represents 31 % of the total stock. The high value of the latter may be explained by the country's geographic location. Cape Verde holds four international airports, one of them (in Boa Vista Islands) is practically aimed at international tourism services. Furthermore, the country has taken advantage of the process of graduation to the middle- income status (international loans at concessional terms) to upgrade its infrastructure in transport, water and sanitation sectors (WTO, 2015).

According to the figures provided by EUKLEMS database (Luiss Lab of European Economics, 2021), the stock of dwellings and other construction structures represented between 80% and 90%

of the total net capital stock in the European Union countries, in the period from 1995 to 2019. As Cape Verde has a low manufacturing base, this ratio is expected to be at the higher tier. The country's GDP in 2014 totalled 1,400.60 million Euros. Thus, the ratio of the capital stock to GDP is estimated at 3.48.

In an international perspective, this ratio seems to be an outlier. In fact, figures provided in (Derbyshire et al., 2013) indicate that the most advanced economies in the then European Union (including Germany, France, The Netherlands and Italy) had, in 1995, a capital-GDP ratio around 3 and the majority of the countries, including United Kingdom, had this ratio in the range between 2.5 and 3. Neo-classic growth theory implies that that the returns of capital diminishes at a rate which depends upon the amount of capital already put in place (Aghion and Howitt, cited in Derbyshire et al., 2013). However, it also implies that the more advanced an economy is the higher the capital–output ratio tends to be because it will be nearer the 'steady sate'.

Be that as it may, Cape Verde has amassed a considerable wealth in built capital stock and has a capital-output ratio somewhat inconsistent with its economic development status. Figures provided by the National Statistical Office (INE-CV- b, various years) show that GFCF represented 35 to 40% of Cape Verde's GDP in the period between 1990.and 2014.

Of course, every developing country aspires to attain the main economy and social targets encapsulated in the *Sustainable Development Goals* (SDGs). As Cape Verde is well positioned for attaining the key targets of de STGs (INE-CV, 2016), it is reasonable to suggest that sound economic considerations should be the primary base for the planning of new construction investment projects.

Concluding remarks

This paper has presented an overview of the Perpetual Inventory Method (PIM) used for estimating capital stock and has discussed some methodologic issues regarding the measures of construction investment and built capital stock. Additionally, based on the results of an earlier work, estimates of the Cape Verde's built capital stock for the year 2014 have been presented. The results of the analysis have shown that Cape Verde has a fixed capital- GDP ratio that is inconsistent with its economic development status.

The role of construction infrastructure in the development process in the less developed countries of the world, particularly in Sub-saharan Africa, has been meriting a special attention from the part of national bodies and international development agencies. As has been pointed out Ruddock and Ruddock (2012), whether infrastructure financing comes from private or public funding, good infrastructure will continue to be a prerequisite for economic and social development in developing countries. However, what matters most is not the amount of infrastructure de per se, but the quality of services rendered by the infrastructures. Thus, the knowledge of reliable data and measurement of a country's stock of buildings and other construction assets are a crucial element for the long-term management of these assets.

Built stock statistics in most developing countries are not disaggregated in a consistent way, letting alone the lack of disaggregation in different built assets, either by type or economic sector. Further studies of individual countries in different stages of economic development would provide a more comprehensive picture of the relationship between construction investment and economic growth and development.

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