Literature Review for Sample Size Analysis in Time Studies

Maria Isabel da Silva[1] and Clara Bento Vaz[2]

[1] Instituto Politécnico de Bragança, Portugal
a52500@alunos.ipb.pt
[2] Research Center in Digitalization and Intelligent Robotics (CeDRI), Instituto Politécnico de Bragança, Portugal
clvaz@ipb.pt

Abstract. An important method related to Lean strategies is Hoshin Kanri which combines operation and strategic management in order to solve both short and long-term problems in companies. Time studies are an effective way in order to apply this method. This paper regards to literature review in time studies of a process. In the literature review, two approaches of defining a sample size are presented: statistical analysis and conventional guide's method, both currently used in some companies. Future analysis of the data collected in a company's production line is devoted to verify whether or not the sample size is adequate, using both methods presented in this work.

Keywords: Hoshin Kanri · Lean Manufacturing · Sample size

1 Introduction

Many companies prioritize short-term over long-term problem solving inside industrial processes. This happens due to the apparent ease in dealing with daily problems in comparison with future ones [9]. However, "having a strategy suggests an ability to look up from the short term and the trivial, to view the long term and the essential, to address causes rather than symptoms, to see woods rather than trees" [4].

Having this in mind it is important to act strategically and focus not only on daily challenges but also on the future ones. Thus, this approach generates added value to the costumers and engaged employees [9]. One of the tools to support a company in the designing of a strategic management is the Hoshin Kanri, which can combine both short and long term problem solving [15].

This methodology consists in two main elements, deployment and planning [13]. Thus, targets and priorities to be achieved in a specific deadlines are set. While demanding commitment to develop solutions by which these targets are reached, Hoshin Kanri builds a link between strategic and operational management [11] [13].

Problem identification is a key factor for the method, hence understanding the process is necessary [6] [16]. This understanding can be facilitated through labor standards, which can be set through the time studies of a process [2].

Several steps are needed to accomplish a reliable study of time [10] [2]. One of them includes deciding how many observations are necessary to measure the time of a given process in order to obtain more-similar-to-reality results. It can be determined by a statistical method or by a conventional guide [17].

In [17] [12] and [2], it is presented similar techniques to do work measurements through the study of time. Those techniques follow a number of steps that are basic principles to generate reliable measurements while estimating the approximated time in which an operator does his job inside a workplace.

However, before knowing the procedure of reliable work measurement, it is important to understand that analysing the job times is a vital task, once it works as input for many analysis inside a company, including strategic planning, estimating labor costs and designing incentive systems [12].

In a production line, standard time is the time that an operator uses to accomplish a task under typical conditions. In order to accomplish the standard time, a qualified worker working at a constant pace is needed. It is also important to consider the layout of the workplace and all the process parameters. A change in any of those factors can also modify the standard time, making it inaccurate [12] [2].

In [2] the steps to determine the standard time are, firstly defining which task inside the production line is going to be studied, secondly, the task needs to be divided into precise elements, that can be called measurement points - this division in small elements is necessary because, some of them may not be performed in every cycle and it can be identified whether or not the worker's proficiency is similar for all the steps [12]. Thirdly, it is necessary to define how many times the task will be measured. That means how many job cycles should be analyzed to bring up the more precise results. Finally, every parameter is decided, the time is recorded and the average (arithmetic mean) is calculated. That considering the adjustments for unusual factor - by eliminating some observations measured in which the operator did some unusual thing due to, for instance, a machine problem or interruptions of any kind [2].

The third step related to sample size will be the focus of this work and will be discussed in the next sections. Therefore, the present work aims to review the current literature for statistical analysis regarding to the sample size currently used in the time studies in a company's production line in which Hoshin Kanri methodology has been implemented.

2 Literature Review

A review of the existing literature concerning the theme of this paper started with the search for "Hoshin method" in Scopus platform, once it is important to give an overview about the importance of sample size in strategic management methodologies. There were about 158 results for the research mentioned above, in which 45 were about engineering and/or management from the past 5 years. The mental map used to start the research is represented by Fig.2. [6] gives an overview of the labor standard importance and [2] presents that it can be set through time studies.

Concerning strategic management, [9] and [4] give an overview of the current state of some companies and their industrial processes. With [9], [15] [11] and [13] it was

possible to understand the method of Hoshin Kanri. Mainly in [11] and [13] it is showed the link between operational and strategic management brought through Hoshin Kanri method. [4], [16] and [10] gave also a good base for Hoshin Kanri theories, introducing the labor standards and time studies.

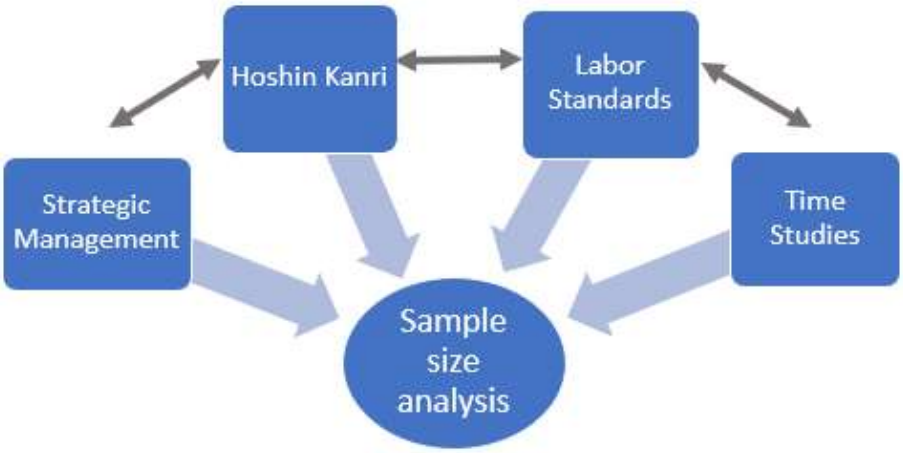

Fig. 1: Scheme of the mental map used for starting the literature review

Table 1 summarizes the time studies found in the literature. In [12] and [2], the concept of standard time was introduced, as well as in [2] the equation of sample size in time studies was presented. [12] and [2] also presented steps to measure the times, while [12] presents only 4 steps, [2] divides it in a more detailed manner, specifying that is necessary to make a division of the process into small elements. [10] focus on the third step, according to [2], that concerns sample size.

Although [1] and [10] give a good overview about statistical analysis of sample size, it is in [3] that it is presented some suggestion on values of accuracy and level of confidence. In [2] it is highlighted the influence of subjectivity in the measurements and the possible imprecision in final results.

Table 1: Summarized literatures on time studies

Reference	Description
[17]	Overview of time studies
[10]	Presentation of statistical and mention of convention approaches
[2] [12]	Overview of time studies and statistical approach
[1], [2],and [3]	Similar statistical approaches with case studies
[7] and [18]	Convention guides approaches

An important fact to mention is that almost all papers in time studies present similarities, once they mention an overview and also focus on the statistical approach of the sample size. It is important to state that [1], [2] and [3] present case studies regarding to statistical analysis, using it to estimate the sample size. Conventional guides was firstly mentioned in [10].

For the conventional guide method, not much was found. Although [7] and [18] present statistical method as well, they give further information about the conventional method, that is an interesting alternative used by some companies, as General Eletric [7] to estimate the sample size based on the minutes spent in the element for which the time is being measured.

3 Time studies

3.1 Statistical analysis

While measuring the times for operators in a production line, in which the jobs are repetitive, statistics techniques can be used to determine the required sample size or the number of observations equal to n, to provide reliable results, in a given level of confidence [1].

The sample size formula in time study work measurement is based on the normal distribution, considering the following parameters, according to [3] and [2]:

$\overline{x}$: mean of the observations.
s: standard deviation of average time from the preliminary observations.
z: number of standard normal deviate (or z-score) corresponding to the desired level of confidence selected.
p: desired precision or accuracy.

Hence, the number of observations is given by equation (1).

$$n = \left(\frac{z.s}{p.\overline{x}}\right)^2 \tag{1}$$

In order to illustrate the application of equation (1), a preliminary time study is conducted. In the first step it is necessary to define the number of observations required. Gathering more data through this first step makes possible to estimate new parameters and calculate a new sample size required for a particular confidence level [3]. However, some of the approaches can check if the precision resulting from a feasible sample is justifiable, since the sample size can be based on economic constraints.

Once it depends on human perception, the approaches mentioned above are susceptible to subjectivity, which is not incorporated into the model. That may cause an erroneous decision on sample size for not representing reality correctly [2]. The level of confidence and accuracy, for instance are parameters that depends on one's judgement. For the

first one, a low number could be not good enough to bring up good results and a 100% confidence could have big cost during the analysis [3]. Although any level of confidence could be chosen, most approaches use 95% and 99% [3]. In [12], it is stated that the accuracy level usually is ±5 %.

Also the standard deviation can generate imprecision, once it is rare that the value of s (standard deviation of the preliminary sample) described in the equation (2) is exactly equal to that of subsequent samples. [8].

$$s = \sqrt{\frac{\sum(x_i - \overline{x})^2}{(n-1)}} \tag{2}$$

Where:

s: standard deviation of average time from the preliminary observations.
x_i: value of each observation
$\overline{x}$: mean of the observation
n: sample size of the preliminary observation

If the sample size resulting on the equation (1) is less then what it was used in the beginning of the analysis, it means that the sample size must be increased. For example, considering a simple production line for an automotive company in which the operator A produces the product X in a specific cycle, going from the machine 1 to machine 2, and in turn, going to machine 3 and then returning to machine 1. This cycle is measured considering a preliminary sample size of 20, after that, one calculates the most adequate sample size by using the equation (1). Supposing that the n resulted was 30, the next step is to measure the cycle 30 times, changing to the new values of $\overline{x}$, x_i, preliminary sample size and consequently, n. This will happen many times until one gets an adequate value for the sample size [7]. Figure 3 illustrates the statistical method described.

By doing this method, one can find out that either a larger sample is needed or that the sample taken was adequate for the measurements [7]. However one disadvantage for this method is that, because of the number of iterations that may be done to reach the adequate sample size, the time spent for this sample size analysis could be high, and this may be costly for a company that will need an employee to perform these time consuming analyzes. Any how, in general, it is necessary to understand that the formula 1 gives approximated results and the more iterations are made, the more accurate the results can be, which is interesting, considering the importance of time studies into a company's performance parameters [14].

3.2 Conventional guide method

The statistical method is susceptible to several inaccuracies [2]. Besides, according to [7], the method is valid, only if it is confirmed that the observed variations are due to chance and are not made intentionally by the operator and it is also a laborious method, once

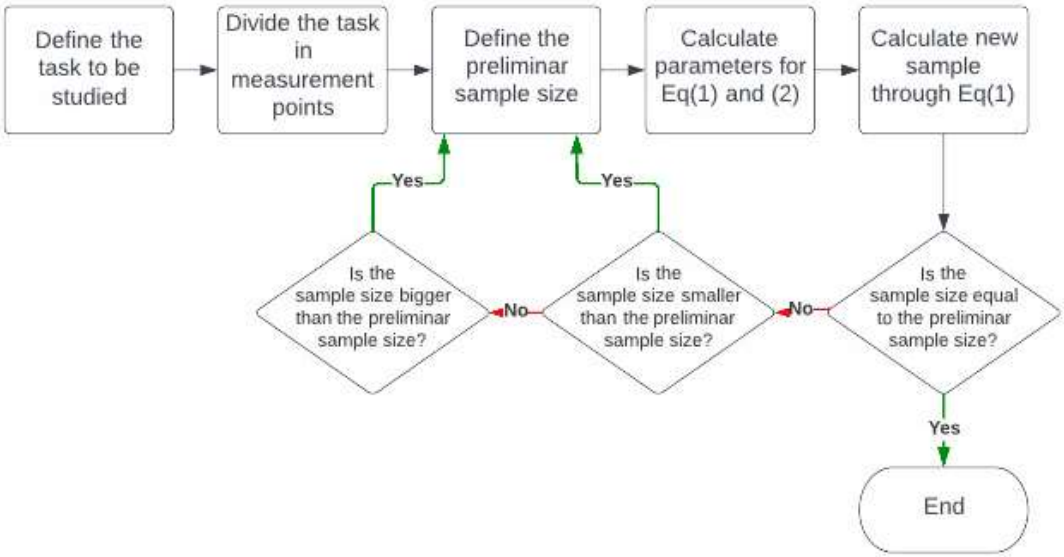

Fig. 2: Fluxogram ilustrating the statistical method

a given cycle is composed of several elements. Until an adequate number n is found, the sample size may vary for each element within a given cycle. This fact results in calculating the sample size for the element that, within the process, needs the largest sample size.

As a consequence of this fact, [7] presents a conventional guide for the number of observations, the sample size to be collected, based on the total number of minutes per cycle, which is summarized in the Table 2 [18]. In the case of adopting the conventional, it is important to make the observations continuously, once occasional elements, also called periodicals, may appear [7]. For this convention it is also important to ensure that periodical tasks are observed in a pattern several times.

Table 2: Number of recommended cycles for time study [7]

Minutes per cycle (min)	0.10	.25	0.50	0.75	1.0	2.0	5.0	10. 0	20.0	40.0
Number of cycles recommended	**200**	100	60	40	30	20	10	8	5	3

Therefore, for the company time studies, this method can also be adopted, once the total time in minutes taken for each activity of each operator inside the line in analysis is usually between 1 and 2 minutes, which imply a sample size of 20 measurements according to Table 2 [7].

Once this method is based on a previously-defined table, it may be susceptible to subjectivity and may also cause an erroneous decision on sample size. Additionally, the fact that sample size is not chosen by making iterations continuously, it maybe slightly imprecise when compared to the statistical method. However, it is used in many companies as General Electric [7], since it is not a time consuming method. On the 3 below, it is possible to see the illustration of the conventional method.

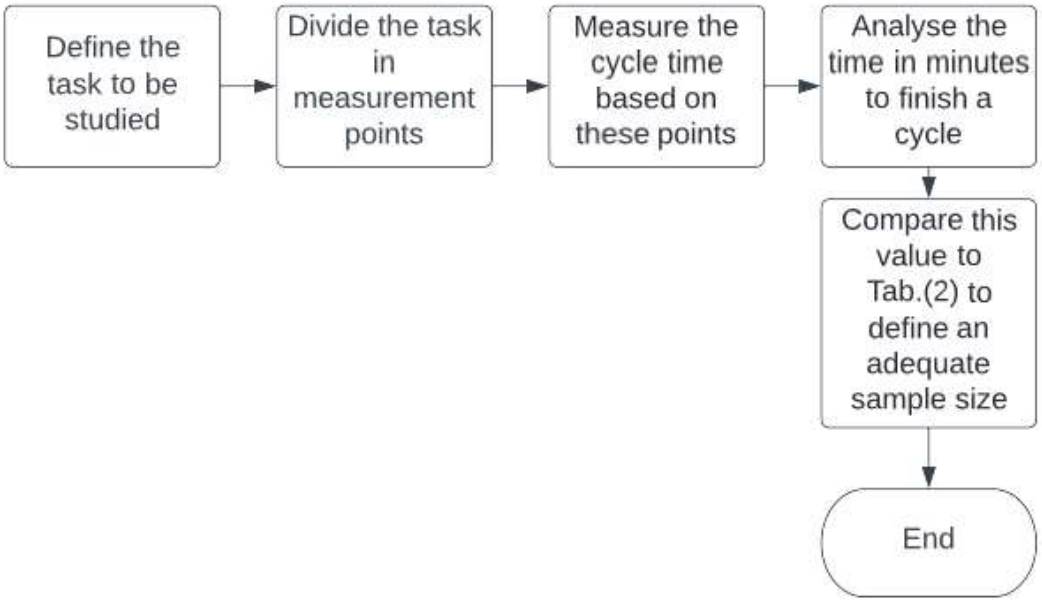

Fig. 3: Fluxogram ilustrating the conventional method

4 Conclusion

Visualizing the global need for time studies related to efficiency gains in processes, in the calculation of costs associated with products and in various performance parameters, it is important that the sample size to perform the time analyzes is as adequate as possible

Thus, with the present paper, it was possible to understand the similarities between the approaches used to estimate sample size for time studies in several areas. For the production lines, it could be verified that both conventional guide and statistical method could be applied for checking if the current sample size used for measurements inside a company is adequate.

For future works it is expected that an automatized spreadsheet will be created to estimate and verify those sample size, using both conventional guide and statistical

methods mentioned in this paper. The development of statistical data treatment will be made the times measured for future works, focusing on the statistical method mentioned.

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