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Digital business case: scientific contributions for a digital framework from benefits realisation management

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Abstract: Nowadays, the pandemic situation has put several businesses in constant uncertainty, with additional concerns for professionals who aim to initiate or evaluate a project endeavour in the context of digital transformation. Thus, the constant market change needed a scientific approach to overcome such uncertainty. The new digital business case was raised with the intuit of providing a business case framework towards the new requirements and needs from professionals by adopting the concept of scientific management and incorporating several new mathematical and statistical methods. This tool was the natural evolution of the business case tool (BC Tool). In order to validate the effectiveness of this new tool, it was used to elaborate on the previous business case with the business case tool and apply the new scientific developments. The results have proven that the digital business case provides a more reliable, and comprehensive benefit and cost estimation analysis in the business case project evaluation.

Keywords: business case; digital transformation; project evaluation; scientific management.

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1 Introduction

The coronavirus (COVID-19) pandemic has changed and influenced, significantly, the global economy and environment (Bai et al., 2021). The current enterprise and organisational world that we knew had to change and adapt to the new reality since COVID-19 is increasing the fragility of the whole system and it is also changing the way in which companies and institutions create, share and capture value (Acciarini et al., 2021). The constant technological changes, the intensification of competition, the markets globalisation and the search for the efficiency of internal processes are some of the key challenge's organisations are facing (Basadur et al., 2014) moreover, due to COVID-19, companies, mainly micro and small enterprises (MSEs) were more affected when compared to larger and global firms (Shafi et al., 2020). Thus, companies had to change their investments decisions, apply new methodologies of projects evaluation, innovation improvement (Sumrit, 2020), capture new ways of funding schemes and allocate resources more wisely. In other words, companies had to reinvent themselves. To face this new reinvention, the business case becomes a crucial tool in order to reaffirms companies in methods, processes, response thresholds and actions to protect enterprise goals, earnings and capital. The current uncertainty led to a new economic and social reality. Organisations must turn problems into opportunities for improvement, creating value and developing sustainable competitive advantages. Management is confronted with the increase of intensive complexity and unexpected problems and those uncertainties might lead to failure or destruction of organisations added value (Ellert et al., 2015) or projects endeavour. To reply to this complexity efficiently, the decision-maker should know how to recognise and utilise the information to take advantages from opportunities in a timely fashion (Devi et al., 2020). Therefore, the business case become not only as a support decision tool but a comprehensive framework for business sustainability in order to avoid arguments and decisions based on reasoning fallacies (Vrbová and Müllerová, 2021).

In order to implement a certain strategy or product into the market is necessary an evolution and the current business case tools (BC Tools)/framework do not reply to the current needs in terms of using the right processes, choose the stakeholders and select reliable data. In some cases, for instance, Murphy and Simon (2001), the business case evaluation is based in a single cost benefit analysis. Consequently, with the current situation, where is also necessary for a successful project digitally meet the demands of the business landscape, it is fundamental a digital business case aligned with the current digital transformation process where companies must leverage their capabilities to overcome a fundamental issue of translating explorative innovation efforts into exploitative value that is a key challenge when dealing with innovation and one of the main barriers for the digital transformation (Colli et al., 2021). The digital transformation is set to be the strategic transformations of organisational changes implemented through digitalisation projects, with the goal of enabling major business improvement (Warner and Wäger, 2019). Thus, it is fundamental to implement a business case methodology,

which can deal and respond to these digital challenges as well to highlight that disruptive transformation that must be viewed as a strategic investment.

The real value of digital transformation investments relates to long-term revenue growth, not short-term technology return on investment (ROI). To maximise the impact of project digital investments, business and technology leaders must learn to value such investments through the eyes of the company's customers.

The digital transformation aims to correspond to these new challenges and needs not only it was during the COVID-19 pandemic but, as well, before the pandemic outbreak where Verhoef et al. (2021) identified three stages of digital transformation: digitisation, digitalisation and digital transformation. The first stage described by Verhoef et al. (2021) is the digitisation. The digitisation is related with the transformation of work processes and activities into digital formats (Alshawaaf and Lee, 2021). The second stage, mention by Verhoef et al. (2021), is the digitalisation. The digitalisation aims embracing new ways of doing business, using new capabilities to serve customers and designing organisational processes to become more agile (Hoe, 2019). The digital transformation has been described in the introduction. Each one of the three stages contributes to enhance the capability of projects decision and improved efficiency and manageability of the decision-making process (Horal et al., 2020). Regarding the three stages of digital transformation contributions to a business case, the digitisation contributes to the process of value creation, value capture and value proposition (Alshawaaf and Lee, 2021), which can be applied to a business case in order to increase its efficiency along the different steps, mainly optimising existing processes to increase overall efficiency (Loebbecke and Picot, 2015). The digitalisation contributes to value creation (Ribeiro-Navarrete et al., 2021) as well it calls for new capability areas and that existing frameworks need to be updated (Kerpedzhiev et al., 2021).

The digital transformation have, fundamentally, altered consumer's expectations and behaviours, pressured traditional firms, and disrupted numerous markets (Verhoef et al., 2021). Thus, to enhance organisational performance using digital technologies is important to invest in a machine learning (ML) strategy, according to Tabrizi et al. (2019), where digital transformation should be guided by the broader business strategy.

In the framework of these developments, the business case methodology is already being applied to several digital transformations processes in several cross-segments. For instance, Martínez-Morán et al. (2021) developed a business case regarding the digital transformation of the talent management process while Zulfikar et al. (2018) applied it to a Malaysian-based university. Thus, a business case methodology is a considerable and reliable method to implement a successful digital transformation process in different segments.

Following the current needs in terms of projects evaluation, in the frame of digital transformation, market requests, projects feasibility and scientific and technological developments it has been implemented new mathematical and statistical methods in the actual framework (BC Tool) which led to the development of a new business case framework towards the digital transformation, project assessment and value creation in an organisation. These developments led to the development of the digital business case. This framework combined the latest scientific innovations from the BC Tool (Pereira et al., 2021a, 2022) with the new ML scientific developments. In other words, this tool aims to apply the concept of scientific management, the application of mathematical models and computing technology, to help decision-makers solve problems (Taylor,

2013). These developments lead to the increase efficiency of the process of the decision-making as well to increase the current state-of-the-art of the business case.

This paper is organised as follow, a brief literature review about the traditional business case, the BC Tool and business cases applied in a context of digital transformation, followed by a description of the new digital business case model. On the next sessions, it will be described the new mathematical and statistical models and their applicability to the use case, which has been previously explored by the BC Tool. The last sections are the conclusions including a paragraph with the project limitations and future work.

2 Literature review

In the next sections, it will be describe succinctly the business case, BC Tool and the business case in a digital transformation environment.

2.1 Business case

The development of a business case is part of the project lifecycle, namely the project feasibility phase. The feasibility phase assesses the business case to confirm it is feasible to implement certain undertaking. The objective of a business case is to verify the economic and financial viability of an investment initiative in a company/organisation. In other words, the business case is an independent and rigorous evaluation process of an initiative that aims value creation in the organisation through the application of its financial, human and time means, or in other words, a business case consists of a decision-making tool to determine whether an investment will create value (BCBOK®, 2015). It summarises anticipated benefits while considering alternative options and recommending a preferred solution (Einhorn and Marnewick, 2019). One of the goals of a comprehensive business case for a certain project is to increase value, provide a competitive advantage, generates business benefits in the areas of business the company is engaged in Johanes and Arviansyah (2020).

2.2 Business case tool

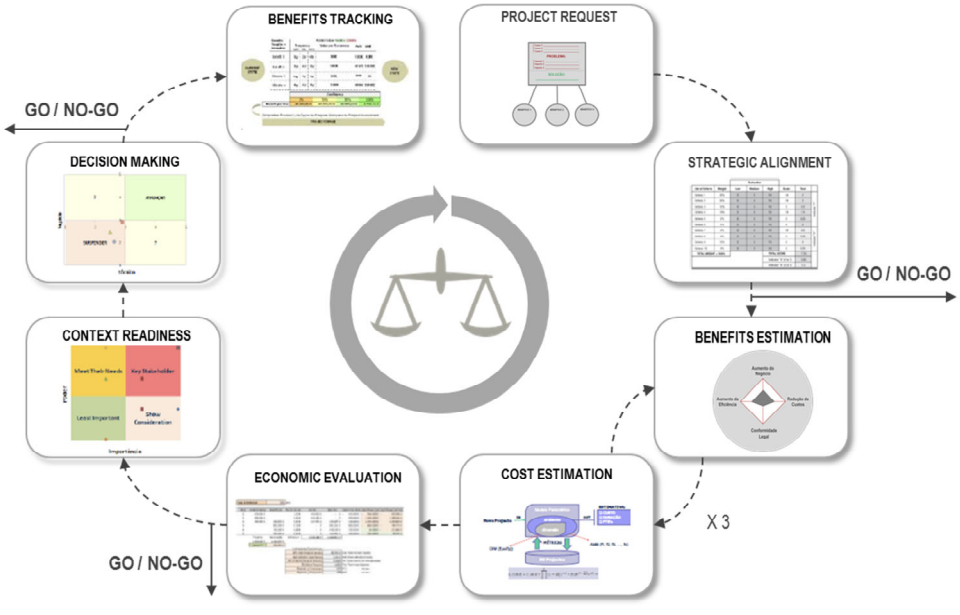
The development of the BC Tool was based in the methodology presented in the BCBOK® (2015). This tool aimed to overcome the current gaps in the traditional business case structure. According the BCBOK® (2015), most business cases in organisations are nothing more than Excel Games (‘Excel Mania’) loaded with addicts and assumptions dipped in a dubious and highly questionable logic in order to ensure that a project or endeavour is feasible and should be adopted (BCBOK®, 2015).

The BC Tool is a tool that uses different algorithms and methods to support and choose the best investment decision based in several outputs provided by the conjunction of different inputs and tools and techniques. BC Tool does not relay only in empiric evidence or one key performance indicator (KPI) for project evaluation, it allows also the use of other metrics, for instance social return on investment (SROI) (Pereira et al., 2021a). This framework aims to support the decision-making process regarding the implementation of a successful business strategy. This tool is considerable eclectic and can be applied to several vertical markets (Pereira et al., 2022).

The BC Tool includes a set of knowledge, skills, tools and techniques that, when properly applied, enable quality and sustainable decisions to be made in alignment with the company's objectives and the requirements of the investment initiative or project.

The BC Tool was developed based in the BCBOK framework of eight steps (Figure 1).

Figure 1 Business case framework (see online version for colours)



Source: BCBOK® (2015)

The current steps are:

1 project request

2 strategic alignment

3 benefits estimation

4 costs estimation

5 economic evaluation

6 context readiness

7 decision-making

8 benefits tracking.

Each one of these steps is well described in the BCBOK® (2015) and by Pereira et al. (2021a, 2022). The all process of the BC Tool is interlinked and with successive steps of go/no go. This does not mean the project should finish but rather that other measurements should be taken in account in order to have a successful project.

2.3 Business case in a digital transformation environment

The current application of a business case in a digital transformation context or need has been already explored by some authors. In Section 1, it has been mentioned two use cases where a business case has applied to two different context of a digital transformation process. Zulfikar et al. (2018) described the adaptation to the dynamic demands, tools, and other technological changes that can be overwhelming in the context of a digital transformation in a university. Martínez-Morán (2021) refers to the digital breakthrough, together with the growing panorama in the competition for talent associated to the talent management process. Other authors, such as Correani et al. (2020) mention that is needed a substantial change in the business model as well on projects implementation to achieve this change and transformation.

3 Methodology

The presented methodology was developed in order to reply to the current needs of methodology and methods for project evaluation using a business case. This methodology aims to reply to the current market globalisation and technology development leveraged by the digital transformation, which are leading to an increase competitiveness with a considerable high level of value creation. The new developments lead to the development of a digital business case methodology assisted by scientific methods, based in the principles of the scientific management, in order to increase its added value and value creation, which will support the process of the decision-making in a project evaluation having positivism as an approach rather empiricism.

In this paper, it has been evaluated the same dataset used by Pereira et al. (2022). This dataset will be explained in more detail in Section 6. The exploration of the same dataset aimed to evaluate the benefit of applying these new developments (integrated into a new digital business case) compared with the BC Tool in a specific business case. This business case was evaluated in the frame of benefits and cost estimation of several activities in some services in a social institution. In order to compare the results, it was compared the final conclusions of Pereira et al. (2021a) and the ones obtained in this paper.

4 Digital business case

The implementation of a digital business case towards a digital market is a considerable added value for future project investments whether this project is strategic and will generate wealth for the company/organisation. Therefore, the development of a digital business case application, oriented to project management, at the level of good practices and which includes a variety of statistical models and algorithms can become a fundamental tool mainly due to the lack of adequate solutions that allow for a transformation into highly reliable information.

Based on this assumption, that is, the difficulty of organisations in adopting a business case to the current reality and to have a tool based in a scientific method which will help organisation to reinvent their operations through the entire lifecycle, starting from customer acquisition and operations to post-sales service and customer service, the

digital business case emerged. This scientific tool will provide a set of project management modules oriented towards the development of a business case that will allow greater strategic agility in identifying the current state and subsequent transformation to a future state in which the needs of customers are met users. Thus, the digital business case is a scientific tool which incorporates the scientific management philosophy, to solve the decision-making problems of an investment decision. This digital business case applies mathematical models to investment decision problems (Taylor, 2013) in several cross-thematic subjects that seek a digital transformation in their organisation.

The digital business case is the natural scientific evolution of the BC Tool due to current market needs, business developments, projects value creation and digital transformation processes. Several steps (4) presented in BC Tool were updated with ML algorithms. The updated steps were the following ones:

1 project request

2 benefits estimation

3 cost estimation

4 economic evaluation.

The digital business case modules will be described in detail in the next section.

5 Digital business case modules development

The update and development of new techniques for four steps of the business case framework (Figure 1) aims to provide a support decision to the process of decision-making, to merge the scientific knowledge with the social sciences and to optimise the process of value creation. The fact that the authors rely only on four steps instead of all the framework of the business case value chain was related with the following reasons:

- The project request is the first step of the business case proposal (BCBOK®, 2015). One of the applied techniques according the BCBOK® (2015) is the problem solving. This technique, nowadays, has been benefiting from the current developments in the field of the natural processing language (NLP). Thus, the incorporation of such technique increases the capability of the decision-making process which will be described into more detail in Section 5.1.1.
- The benefits estimation, cost estimation and the economic evaluation are methods based on a quantitative approach and are measurable. Thus, there are several statistical models that can be applied in order to increase its efficiency and added value to project evaluation.
- These four steps from the initial five are the main inputs for the business case evaluation. The digital business case aims to focus on the first step which leads to a go/no go decision as well to the quantitative measurements of cost estimation, benefits estimation and economic evaluation, which will lead, as well, to a go/no go decision.

5.1 Project request

The project request process aims to formalise the initiative request in a standard way (BCBOK®, 2015). This is the very initial step and assumes several inputs, tools and techniques and outputs. Among the techniques applied, the problem solving is one of the most used and welcomes technique. In the BC Tool, this technique is the initial step and was adapted from the proposed problem solving framework from Pereira and Santos (2020). and has upgrade in order to correspond to the current scientific developments and market demand.

In a project request, the problem solving is one of the most common applied techniques. Currently, complex problem solving is one of the main competences needed to maintain and address the complexity of the current business world (Pereira et al., 2021b). Thus, it is inclusion as a fundamental technique is a considerable added value.

5.1.1 Problem solving

Contrary to the project lifecycle where the business case is incorporated in project feasibility phase the strategy adopted by the problem solving approach is to relate how Business case establishes a strategy to solve corporate requirements.

In order to face a growing and complex market, the application of problem solving mechanisms to overcome the lack of solutions and time consuming led to the implementation and use of text miming algorithms with the aim of obtaining supporting knowledge discovery (Sinoara et al., 2017), which can be translated in a more efficient method of decision support in problem solving frameworks.

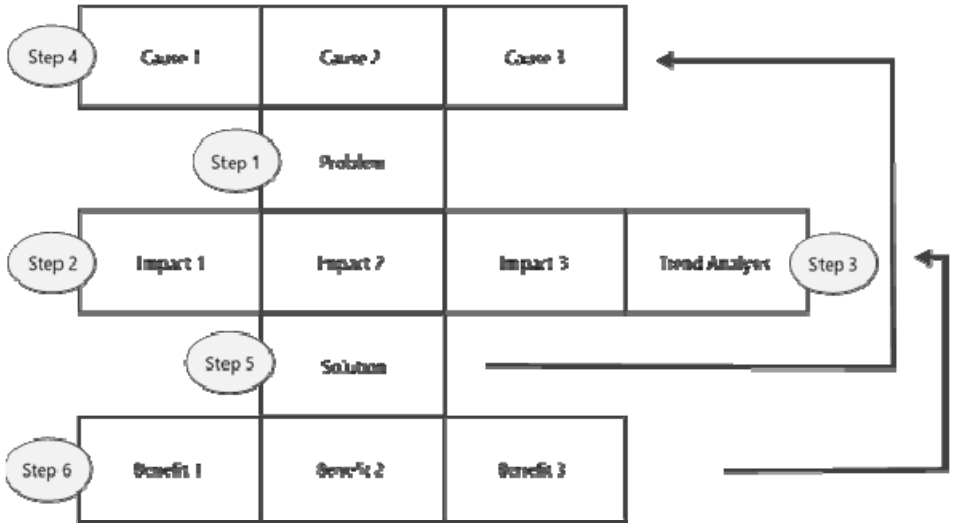
Problem solving means a conflict or a difficulty, which must be overcome during the solution process (Dostál, 2015). Often, the complexity of the processes and the constant change make it difficult to identify the solutions that effectively solve organisational problems. Therefore, it is crucial to understand the contribution of a problem solving approach for organisations in order to solve, in a more concise way, several types of problems containing different needs of skills, knowledge and tactics.

The implementation of this development was based in the problem solving model (Pereira and Santos, 2020) available in Figure 2. The Pereira problem solving model is a qualitative approach to solve a given problem. This technique states that the first step after a problem is identified, is to define and analyse the main business/process impacts using Pareto principle (up to three impacts should account for 80% of the effects of a particular problem) and their trend analysis over a certain period. This first phase is very important because the trend analysis done for each impact identified allows problems to be prioritise (Pereira and Santos, 2020). When the impacts justify moving forward with the problem solving process, the next step consists of collecting the causes that originate the problem, based on the different root-cause techniques that exist. This step allows the analyses of the current situation (AS IS) to be finished. Afterwards, according to Pereira problem solving model, all the conditions needed to propose a solution are met, therefore, the last step is to define the solutions and benefits that mitigate the causes already identified (Pereira and Santos, 2020).

Although, the implementation of this framework has been accomplished in the BC Tool and applied to two use cases (Pereira et al., 2021a, 2022), this framework consisted into a static module without any previous knowledge or even connection among the causes, impact or benefits. Thus, this new module developed using the baseline of this

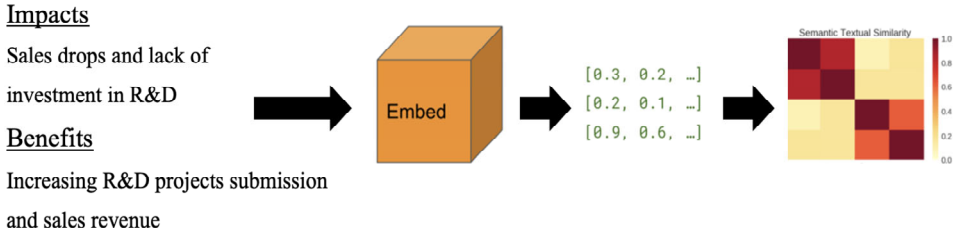
methodology approach added one important contribution, the NLP algorithm. The NLP is gaining momentum in management research for its ability to automatically analyse and comprehend human language (Kang et al., 2020). With this new development, it is possible to extract the semantics of words and sentences from the benefits and impacts in order to compare them in terms of words relation. In this way, it will be possible to measure the relation between these two steps and to validate if the level of connection and similarity are equal. Thus, if the desired benefit corresponds to the current impact of the problem. Using this scientific approach, it will be possible to increase the efficiency of the benefits since it attribute a probability estimation (from 0 to 1) of each word/sentence related with the impact with a semantic textual similarity (Figure 3).

Figure 2 Pereira problem solving



Source: Pereira and Santos (2020)

Figure 3 Semantic textual similarity (see online version for colours)



The combination of these identified techniques requires a very high complexity which, however, will allow a considerable advance from a scientific point of view and which will translate into advantages far superior to the current problem solving model. The automation of this process will allow a considerable reduction in the empirical time spent by a team as well as the subsequent analysis of all fields of information provided. The

major development of this module will allow for considerable scientific analytical and predictive advancement for the subsequent modules.

5.2 Benefits estimation

The benefits estimation is a fundamental step in any business case since it aims to assess the impact of project benefits quantitatively in the business and in the company (BCBOK®, 2015). This step intended that the benefits are calculated through a robust process, so they are presented in a rigorous, accurate and conservative manner. In benefits estimation, the process of benefit modelling aims to assess the impact of project benefits quantitatively in the business and in the company. It is intended that the benefits are calculated through a robust process, so they are presented in a rigorous, accurate and conservative manner.

Among the several available techniques applied in benefits estimation the parametric analysis is one of them. Although and due to the project's nature, data availability and needs the non-parametric approach seems a logical technique which can provided an added value in terms of benefits evaluation. Besides the implementation of a non-parametric model, it was implemented. In the next section, it will be describe in detail the statistical models implemented.

5.2.1 Parametric and non-parametric analysis

The parametric model is one of the most accurate and reliable methods based on historical data and parameters from previous projects of the same type. It implements a mathematical model with statistic and capabilities analysis of any existing cause-effect relationship between variables, turning it on a valuable contribution to the initiative under analysis (BCBOK®, 2015).

The parametric analysis has been commonly used in estimating the benefits of a project that can derive from very complex and opposite themes. However, these parametric methods (Asmare and Begashaw, 2018) assume that distributions are normal and, although, these models can have a more accurate estimate, they are considered methods less robust besides the fact that conducting the parametric approach is how to appropriately distinguish random noise from true in efficiency, as neither of them is observable (Huang and Wang, 2002). In this paper, an alternative was provided to the current use of parametric analysis for benefits estimation. In this paper, it is presented a non-parametric approach. The non-parametric methods are applied in highly complex themes in which the data does not have a normal distribution and are resistant to transformation. The scientific added value of this new methodology as well as the application of a scientific method will allow an increment in its technical development. This alternative will extend the estimation capacity of the models/data used in a way that will allow better analytical and assertive results regardless of whether the distribution is normal or not. Among the panoply of existing non-parametric methods, the Friedman test will be incorporated in this step. The Friedman test is a non-parametric statistical test developed by Friedman (1937). It is used to detect if an ordinal factor (dependent variable) has any statistical difference between several groups (Irigaray et al., 2019).

In the implementation of the Friedman test to the benefits estimation (which can be vary from n to $n + 1$) it is described, initially, the ordinal variables which are the ranked benefits value estimation. In the digital business case framework, it is implemented to

determine if there are statistically significant differences for comparisons of multiple groups, with different factors for each benefit. For instance, regarding the configured statistical significance (95%), the hypothesis that all benefits contribute similarly in terms of value to the business case is valid.

This non-parametric analysis uses the Friedman test to evaluate how each benefit contributes to the success of the business case, and act as a guidance tool for the benefits evaluation. Depending on the significance level, if the result is 'reject null hypothesis and accept the alternative', then it means that one of the benefits has a much larger impact on the business case. To validate or reject the null hypothesis, it has been undertaken several steps:

1 Null and alternative hypothesis:

H0 All benefits contribute similarly in terms of value to the business case.

H1 At least one benefit brings greater impact to the business case.

2 State alpha

$$\alpha = 0.05$$

3 Degrees of freedom

$$df = k - 1, \text{ where } k = \text{number of groups}$$

$$df = 3 - 1 = 2$$

4 State the decision rule

This step is applied to look up to the critical value in the chi-square table and find a critical value of plus/minus 5.99. That means, a statistical value ≥ than 5.99 means that the null hypothesis is accepted in the opposite ≤ than 5.99 means that the null hypothesis is rejected and accepted the alternative.

5 Calculate test statistics

The benefits estimation values for each benefit are then ranked and insert in the Friedman equation. These values are used as input. The Friedman test equation is computed as equation (1):

$$\chi_r^2 = \frac{12}{nk(k+1)} \sum R^2 - 3n(k+1) \tag{1}$$

where K is the number of benefits and N the number of rank variables for each benefit and R the final rank.

5.3 Cost estimation

The module cost estimation process aims to get a cost estimate for the project. This estimate should include not only the cost of the project but also the new operational costs (BCBOK®, 2015). In terms of applicability, the cost estimation is one of the most significant steps in construction planning, which must be undertaken in the preliminary stages of any project (Al-Tawal et al., 2020) as well the main criteria for decision-making at the early stages (Ambrule and Bhirud, 2017).

In cost estimation is included the topic product definition, product breakdown structure and the cost breakdown structure. The product definition process aims to define what costs may be involved in the project. The product breakdown structure process aims to qualitatively assess whether a particular initiative has costs that are not aligned with the benefits defined and the cost breakdown structure process aims to get a cost estimate for the project. This cost breakdown estimate should include not only the cost of the project, as well as the new operational costs.

In this segment, several new algorithms have been applied in order to provide an added value. Among the different developed and implemented methods, it will be described in the next sections forecasting, Pearson correlation and Bayesian probability.

5.3.1 Forecasting

In a business case is an added value the possibility to forecast the products price estimation. In the digital business case, it was implemented the simple moving average (SMA) in order to perform the product cost estimation and analysis for the following years. Based in this information, the decision-makers can have the decision of change products, validate costs or find an alternative to be in line with the project needs and requirements. The SMA moving average is a simple weighted sum calculated over a selected historical price range (Raudys and Pabarškaitė, 2018). It is widely used to estimate the current level of a time series, with this value being projected as a forecast for future observations (Johnston et al., 1999).

The SMA equation in computed as equation (2):

$$SMA = \frac{A_1 + A_2 + \ldots + A_n}{n} \tag{2}$$

where the A_1, A_2, A_n are the product cost for each year and n stands for the number of data prices used in the calculation. It varies in function of the cost number introduced in each year.

5.3.2 Correlation coefficient

Another important statistical method applied in the module cost estimation was the introduction of a correlation coefficient in order to measure the level of association between the different products forecasted defined for the current project. From the panoply of existing methods, the selected coefficient was the Pearson correlation. This correlation method measures the linear dependency between two random variables (Ly et al., 2018).

In terms of significance, the results obtained from the Pearson correlation according to Schober et al. (2018) are the following:

- A correlation coefficient of 1 means that for every positive increase in one variable, there is a positive increase of a fixed proportion in the other.
- A correlation coefficient of –1 means that for every positive increase in one variable, there is a negative decrease of a fixed proportion in the other.

- Zero means that for every increase, there is not a positive or negative increase.

The applied equation is computed as equation (3):

$$r = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2 (y - \bar{y})^2}} \tag{3}$$

where the $\bar{x}$ is the mean of x variable and the $\bar{y}$ is the mean of y variable.

In terms of interpretation in the digital business case, the Pearson coefficient aims to provide the level of association regarding the product cost forecasting between all the products combinations. If the level of association is high among the overall products, it means they could reflect in the variation of the price meaning that one product cost depends on the variation of the other project. In alternative if there is not any association it means the products are totally different and the product cost is redundant among their price variation.

5.3.3 Bayes theorem

The Bayesian statistics can be understood as the conditional measure of uncertainty associated with the occurrence of a particular event, given the available information and the accepted assumptions (Bernardo, 2004). Bayesian methods provide a complete paradigm for both statistical inference and decision-making under uncertainty (Bernardo et al., 2011). One important assumption in the development of a Bayesian approach is the selection of the prior distribution. This prior distribution reflects expert's knowledge about project trends, future threats and opportunities (Caron et al., 2013). The application of a Bayesian approach has several advantages, for instance dealing with information provided by scarce and small samples (Dalla Valle and Giudici, 2008), where statistical power issues make it nearly impossible to support frequentist hypotheses with *p* values (Howson and Urbach, 2006). The application of a cost estimation approach using a Bayesian combination was already tried according to Jorgensen and Shepperd (2006).

The implementation of this model in the cost estimation aimed to calculate the posterior probability of an event, considering the prior probability of an event, activity or other type of numeric subject that can be quantified, namely by defining the probability in three different states: 'increase cost probability', 'stable cost probability' and 'decrease cost probability'.

The applied equation, for calculating the conditional probability with three factors, is computed as equation (4):

$$P(R \mid H, S) = \frac{P(H \mid R, S)P(R \mid S)}{P(H \mid S)} \tag{4}$$

where (R) is the probability of the price being stable given the increase cost probability (H) or decrease cost probability (S).

5.4 Economic evaluation

The economic evaluation of a business case aims to validate if the project is viable or not depending on the defined threshold by the decision-makers. The project should ensure rapid return of the investment and good profitability over the expected lifetime, comparable with other industrial or financial projects (Dimian et al., 2014). The decision about a project moving forward or not, should always consider a minimum trust level from 80% to 95% in the combined cost and benefit cash flows (BCBOK®, 2015). The economic evaluation is commonly used in several different projects without being specific in terms of project nature.

Based in the economic indicators provided in the BC Tool such as the ROI among several other (net present value, benefit cost ratio, internal rate of return, external rate of return/MIRR, net external rate return and payback with interest) the implemented algorithm aims to provide advanced risk analysis for long-term risk evaluation and to be complementary, that means, this algorithm does not pretend to replace the current economic indicators but rather to provide a complementary risk information.

In this module, economic evaluation, it was implemented the Markov chain in order to simulate all the economic evaluation indicators and its respective evolution, using a Markov chain and attributes a probability to each of the three states (low, moderate and high) that represent the risk of the business case model based in years, investments and benefits.

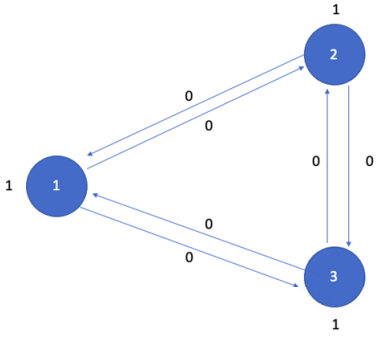
5.4.1 Markov chain

Markov chains are a class of stochastic processes very commonly used to model random dynamical systems (Douc et al., 2018). It is a probabilistic model describing a system that changes from state to state, and in which the probability of the system being in a certain state at a certain time step depends only on the state of the preceding time step (Gagniuc, 2017). It is important to mention that the two most fundamental probabilistic models for sequential data are independent and identically distributed processes and Markov chains. In this step, the main objective is to analyse all the economic evaluation variables and its respective evolution, using a Markov chain and attributes a probability to each of the three states (low, moderate and high) that represent the risk of the business case model as well, as a long-term risk evaluation. The simulation of a homogenous Markov chain is divided in three steps: transition probabilities, state function and Markov graph. The transition probabilities aim to determine how the Markov chain to be simulated looks like at each time (t) when the transition probabilities changes from one state of a given finite Markov chain to another one with finite number x of states. These transition probabilities are given by the following matrix (5):

$$\begin{array}{r} \\ Low \\ t = Moderate \\ High \end{array} \begin{array}{c} \begin{array}{ccc} Low & Moderate & High \end{array} \\ \begin{vmatrix} (xi_1)n & \ldots & (xi_3)n \\ (xi_2)n & \ldots & (xi_2)n \\ (xi_3)n & \ldots & (xi_3)n \end{vmatrix} \end{array} \tag{5}$$

where each element (xi_{n-1}) represents the probability (one step transition probability) for this finite Markov chain to go from the state $xn = x1(i)$ to the next state $x_{n+1} = x(2-3)$.

The Markov graph is computed as equation (6): (see online version for colours)



(6)

Where the numbers on the edges give the transition probability; the numbers at the nodes are the chances to remain in the node. The current state in the current simulation step is highlighted, as well as the last-used edge.

6 Data description

To evaluate the new scientific developments, it has been used the same dataset which was described in Pereira et al. (2022). This dataset is related with the application of the BC Tool in order to contribute and evaluate sustainable measures in terms of benefits and cost reduction to needy families and the decrease the social exclusion of these families affected by poverty. In this paper, it was applied the new developments described previously. By using a dataset which was already been applied in the frame of a business case it will be possible to measure, quantify and validate the added value provided by the new scientific developments. The aim is to analysis if these developments contributed to the project success, evaluation and benefits measurement.

In this dataset, it was 18 services provided by these social institutions. These services are presented in Table 1.

Table 1 Social institution services

1	Health	2	Housing	3	Teaching
4	Work	5	Income	6	Social orientation
7	Basic needs, materials and services	8	Migrants legalisation	9	Other support to migrants
10	Elderly	11	Childhood	12	Social services
13	Domestic violence	14	Homeless	15	HIV
16	Drug addiction	17	Migrations	18	Formation

Although there are provided 18 services, by the social group where this institution belongs, in this dataset, there are only four services (elderly, childhood, social services and domestic violence) which have patients. It is based on these services that it will be elaborated the business case. Allocated to these services, there are several activities. For

each activity, there is a unitary granted value by the Ministry of Social Security to the institution based in total number of patients. Regarding the activities, they will be described in the next section as part of the data integration for the new models. The value granted for each activity, which have patients, is described in Table 2.

Table 2 Unitary granted value

Elderly		*Childhood*	
Activity	*Unitary value (€)*	*Activity*	*Unitary value (€)*
Home support services	261	Kindergarten	265
#	#	Preschool education establishment	265
Social services		*Domestic violence*	
Activity	*Unitary value (€)*	*Activity*	*Unitary value (€)*
Service and social support	60	Call centre	60
Temporary housing centre	550	#	#

To measure the impact and added value from the new developments, following the eight steps of the BC Tool, it will be calculated the new benefits using the digital business case. It is important to mention that the new digital business case, nevertheless, is an extension of the BC Tool. Thus, these new developments were integrated into the new tool and obtained the new outputs which will be analysed in the following sections. The aim of this new data analysis is to validate if effectively each activity provided by each service is or not an added value for the institution regarding the benefit and cost estimation.

7 Results

To evaluate the results, it has been counted as a benefit each activity described by the institution regarding each service. In the dataset from the number of activities and due to the lack of data in some activities without any patient the new model developments were only applied to the activities which have available data. In order to provide a comprehensive data visualisation, it is described in Table 3.

Table 3 Services and associated activities

Elderly		*Childhood*	
Activity	*Patients*	*Activity*	*Patients*
Home support services	3	Kindergarten	35
		Preschool education establishment	37
Social services		*Domestic violence*	
Activity	*Patients*	*Activity*	*Patients*
Service and social support	489	Call centre	303
Temporary housing centre	45		

In this business case, it was not applied the problem solving syntax to the project description due to a level of confidential information, namely the causes and impacts described. Although, it was applied all other developed methods as we will see in the next steps.

7.1 Friedman test

The initial applied method was the Friedman test. This method was applied to all services. It was tested with a confident level of 95% and 90% for H0 (this activity contributes positively in terms of benefit vs. cost to the business case) and H1 (this activity does not contribute positively in terms of benefit vs. cost to the business case). The results were as shown in Tables 4 and 5.

Table 4 Friedman test (elderly and childhood)

Elderly			*Childhood*		
Activity	*95%*	*90%*	*Activity*	*95%*	*90%*
Home support services	Accept	Accept	Kindergarten	Reject	Reject
#	#	#	Preschool education establishment	Reject	Reject

Table 5 Friedman test (social services and domestic violence)

Social services			*Domestic violence*		
Activity	*95%*	*90%*	*Activity*	*95%*	*90%*
Service and social support	Accept	Accept	Call centre	Accept	Accept
Temporary housing centre	Accept	Accept	#	#	#

In Table 4 is validated that the activities in the service ‘childhood’ are all rejected. That means, these activities does not contribute positively in terms of benefit vs. cost to the business case. Based in this assumption, the institution can adopt metrics or a difference policy in order to overcome the rejection of H0 and acceptance of H1. This evaluation is merely quantitative and focuses on the business case evaluation from the benefits point of view and not on the social side. In the other way around, the remaining categories contribute positively in terms of benefit vs. cost to the business case in both confidence level (95% and 90%). The activities from the service social services (Table 5) since were the ones that had a better performance, which means the value mean compared with the rejection value at 95% had a considerable range.

7.2 Simple moving average

In order to obtain a benefit price forecasting for each service it was used, as input, the total number of patients for each month between 2018 and 2019. The selection of the number of patients is fundamental to validate the benefits of each service since their income is based in the total number of patients. The aim is to forecast the number of patients and then obtain, as well, a forecasted value of benefit and cost. Basically, it will be forecasted three variables (patients, benefits and cost). With the output provided by the statistical method SMA, it will be possible to predict future actions and services based in

the potential number of patients. This is a fundamental information regarding the increment of the social association services, activities and healthcare and well-being. Following this assumption, the forecasted values (n + 1), where n is the year, are described in Tables 6, 7, 8 and 9. In this model, SMA, it was forecasted the value for the year 2020, 2021 and 2022.

Table 6 Elderly benefits forecasting

Elderly									
Activity	*Forecasting patients*			*Forecasting benefits (€)*			*Forecasting cost (€)*		
	2020	*2021*	*2022*	*2020*	*2021*	*2022*	*2020*	*2021*	*2022*
Home support services	5	6	5	1,305	1,566	1,305	-	-	-

In the service 'elderly' (Table 6), the number of patients is predicted to increase although and facing the data evolution the year 2022 forecast the same five patients. Although it is not a considerable number of patients for this activity, the patient's average in the last 24 months was around 7. Although, and, during the last months, the requested number of patients have been reduced considerably. Since the value has changed during the last year, we consider that change as well. It is important to mention that the data provided for this field is only based on the past three years (contemplating the benefits given for each patient) thus, it lacks more years of data analysis to provide a more reliable value. Regarding the cost for each patient in this activity, it was not provided by the institution.

In Table 7 is described the forecasting values for the service 'childhood'. Due to the considerable number of patients in both activities during the last two years, the forecasted values were always growing the cost as well which have increased considerably. Based on these results, it is assumed that this service is the one each brings less benefits and a higher cost for the institution. To overcome this potential issue, the institution should adopt a different policy or diverse the number of activities.

Table 7 Childhood benefits forecasting

Childhood									
Activity	*Forecasting patients*			*Forecasting benefits (€)*			*Forecasting cost (€)*		
	2020	*2021*	*2022*	*2020*	*2021*	*2022*	*2020*	*2021*	*2022*
Kindergarten	40	48	56	127,200	152,640	178,080	130,000	153,500	180,830
Preschool education establishment	43	50	58	136,740	159,000	184,440	138,500	160,700	180,900

In terms of social services (Table 8), there is also two main activities the 'service and social support' and the 'temporary housing centre'. In both cases, the benefits have a considerable overcome regarding the cost. For instance, in service and social support the average cost is less than the double of the benefits. In the case of the temporary housing centre, the benefits are more than the double of the forecasting cost. This variation has to do with the price granted for each patient. Since is a considerable value, the rate different are considerable high. Thus, the social activities have a considerable positive impact in the social institution in terms of benefits.

In the last service and last activity (call centre), there is a considerable difference between the forecasted benefits and the cost (Table 9). Although this service has one of the highest numbers of participants the benefit is considerable low if we analyse it in terms of economic impact. On the other hand, it has a considerable positive social impact by providing an added value service to a substantial number of patients. It is worth to mention that this activity has a low granted value for each patient.

Table 8 Social services benefits forecasting

Social services									
Activity	*Forecasting patients*			*Forecasting benefits (€)*			*Forecasting cost (€)*		
	2020	*2021*	*2022*	*2020*	*2021*	*2022*	*2020*	*2021*	*2022*
Service and social support	500	511	521	360,000	367,920	375,120	203,309	248,546	258,985
Temporary housing centre	50	53	55	330,000	349,000	363,000	112,907	119,682	124,198

Table 9 Social services benefits forecasting

Domestic violence									
Activity	*Forecasting patients*			*Forecasting benefits (€)*			*Forecasting cost (€)*		
	2020	*2021*	*2022*	*2020*	*2021*	*2022*	*2020*	*2021*	*2022*
Call centre	330	342	350	19,800	20,520	21,000	57,618	59,713	61,110

7.3 Pearson correlation

The correlation between the several activities and the respective services aimed to validate if there is a correlation among them and if this correlation is positive or negative, that is, if the activity leverages the services of the social association. It is important to mention that Pearson correlation does not take into consideration whether a variable has been classified as a dependent or independent variable. It treats all variables equally.

This calculation was based in the number of patients and the difference between the benefit and the cost. In Table 10, it was not possible to evaluate the Pearson correlation for the service 'elderly' since there is not no data for category 'cost'. In the service 'childhood', both activities have a positive linear relation. Although and compared with other services in Table 11, the association between the activities and the services is still considerable which can be explained by the number of patients and the difference between the benefits and the cost.

Table 10 Pearson correlation (elderly and childhood)

Elderly		*Childhood*	
Activity	*Pearson*	*Activity*	*Pearson*
Home support services	#	Kindergarten	0.60
#	#	Preschool education establishment	0.70

Regarding the services 'social services' and 'domestic violence', described in Table 11, due to the high contribution, in terms of difference value (benefit vs. cost) and the number of patients, in the social services the correlation is considerable high meaning a strong association between the activities and the service. In the other hand, the association between the activity call centre and the service domestic violence has a reduce level of association but still positive which means there are still a linear relation. The low value can be explained by the negative difference between the benefits and the cost.

Table 11 Pearson correlation (social services and domestic violence)

Social services		*Domestic violence*	
Activity	*Pearson*	*Activity*	*Pearson*
Service and social support	0.80	Call centre	0.4
Temporary housing centre	0.89	#	#

7.4 Bayesian probability

The application of the Bayesian probability to the present dataset used, as an input, the forecasted values described in Tables 7, 8 and 9. This model was not applied to the service 'elderly' due to data absence (cost) as mentioned previously. The aim was to calculate the probability of the difference value (percent difference between two positive numbers greater than 0) between the forecasted benefit and forecasted cost. In order to obtain the difference (variable p) between the forecasted benefit and cost it was computed as equation (7):

$$p = \frac{(v1 - v2)}{[(v1 + v2)/2]} * 100 \tag{7}$$

where $v1$ is the benefit and the $v2$ the cost described in Tables 7, 8 and 9.

The aim is to calculate the probability of the result of p [equation (7)] being stable (R) given the probability of increasing or decreasing the services activities differences. The Bayesian probability results are available in Tables 12, 13 and 14. This probability is given between 0 and 1 where 1 means the total probability of changing and 0 no probability of any change. It is important to mention that an activity can have more than one probability per field since is not a constant value. That means, it can have the probability of being stable while can have a probability of increase or decrease the difference value (benefit vs. cost) since the data is based in forecasted outputs.

In Table 12 are described the probabilities of the two activities related with the service 'childhood'. The Bayesian probability for both activities is equal in the probability to reduce the difference between the benefits and the cost. In the case of the activity 'kindergarten', the probability of being stable or increase is equal, thus the chances the benefit and cost being in same situation in the year 2022 will be the same as well the probability of increasing. In this probability, it is assume both variables entered in equation (7) will have the same variation, that means, they are correlated in the sense that if one goes up or down the other will have the same behaviour. In the activity 'preschool education establishment', the highest probability is that the differences will increase. This probability class has a considerable difference to the classes stable and

decrease probability. Thus, it is foreseen that the benefits and cost will continue to increment leading to a considerable increase of both variables.

The activities in the service 'social services' (Table 13) have the same variation. Both have a higher probability of being stable based in the differences between the two variables. In the column 'difference' is observed that both activities have a difference decrease from 2021 to 2022. Although, the class that have a higher probability is still the class stable followed by the class decrease. The class increase is considered null with no probability of changing based in the input data.

Table 12 Bayesian probability in the service childhood

Childhood						
Activity	*Difference (benefit vs. cost) %*			*Bayesian probability*		
	2020	*2021*	*2022*	*Increase*	*Stable*	*Decrease*
Kindergarten	2.17	0.56	1.53	0.57	0.57	0.33
Preschool education establishment	127	106	193	0.75	0.33	0.33

Table 13 Bayesian probability in the service social services

Social services						
Activity	*Difference (benefit vs. cost) %*			*Bayesian probability*		
	2020	*2021*	*2022*	*Increase*	*Stable*	*Decrease*
Service and social support	56	39	37	0	0.75	0.57
Temporary housing centre	98	98	98	0	0.89	0.33

In Table 14, the probability of the benefit and cost increase their difference is 0.33 compare with the probability of being stable which is 0.89. Thus, the activity call centre has a considerable probability of being stable. In the other hand, the probability to decrease is null, therefore is not foreseen that the difference between both variables will have a decrease in the benefits or costs.

Table 14 Bayesian probability in the service domestic violence

Domestic violence						
Activity	*Difference (benefit vs. cost) %*			*Bayesian probability*		
	2020	*2021*	*2022*	*Increase*	*Stable*	*Decrease*
Call centre	98	98	98	0.33	0.89	0

The application of this probability, assuming the value being stable and having the probability of increase or decrease, provide a considerable interesting metrics, which can support the decision-makers in each direction/decision they want to go or to take based in these probabilities. This output can have a social or economic understanding depending on the decision-making perspective and goals. It is trustworthy to mention that the Bayesian probability has a considerable added value for the business case of certain activity, product or relevant subject in order to measure their probability to increase, being stable of decrease the benefits or cost estimation.

7.5 Markov chain

The Markov chain has been applied in this business case in order to validate the economic evaluation of this project. In the BC Tool, as mentioned before, there are several other metrics that provide evaluation methods. Although, using the Markov chain it can be measured the different transition states and have a better overview of the go/no go of the project in terms of economic evaluation. In this project, the results of the risk analysis for each forecasted year (2020, 2021 and 2022) are presented in Table 15. To obtain the transition probabilities matrix it has been used, as input, the forecasted benefits, cost estimation, number of patients and the unitary granted value for each patient in each activity. In the transition probabilities matrix, they are devised referring to the memoryless property of stochastic process which is the conditional probability distribution of future states of any process depends only and only on the present state of those processes. The risk analysis that is measured in Tables 15 and 16 aims to provide and output regarding the social evaluation impact of the services and activities provided in terms of benefits and cost estimation for the social communities that use the provided activities from the social institution.

Table 15 Markov chain risk analysis

Year	*Risk analysis (%)*		
	Low	*Moderate*	*High*
2020	41	13	46
2021	20	33	47
2022	28	24	48

The obtained results indicate for almost all the forecasted years a high-risk analysis of the current business case except for the year 2020 where there is also a low probability of risk. The results are indicative of a high-risk probability of the business case will not have the expected economic evaluation social return social. Thus, it is foreseen, in terms of economic evaluation, that this business case will need new services, activities, less or more patients depending on the activity and a higher unitary grant value for each patient. Although, the year 2020 and 2021 have also a more comprehensive approach in terms of low and a moderate risk analysis. In this case, it depends on the decision-maker to continue the business case or not. It is important to mention, as described before, this is an economic evaluation which congregates the information provided in the last four steps of the digital business case framework and not a social evaluation of the relevant impact from the social institution.

In Table 16 is presented the long-term risk analysis based in the overall analysis of the information provided in Table 15 and the information congregated from the four initial steps of the digital business case. The results are clear regarding the risk analysis of this business case, it is a high risk. Although the probability variation in the class low and moderate have similar probability. Thus, continuing with a business case with a higher risk analysis can compromise the future economic viability of the social institution especially in terms of benefits and cost estimation. It is does not clear the high risk will remain constant or it can reduce or increase in the end of the project. However, this is a module of go/no go thus the decision-makers should stand a point at this step or reformulate the business case with new assumptions. In any case, the decision-maker

should consider, as well, the low and moderate probability risk analysis since it has significance with more than 20% of probability and half of the probability high risk. Thus, the decision can be dubious, and the decision-maker should or could stand for the decision GO.

Table 16 Long-term risk analysis

Long-term risk analysis (%)		
Low	*Moderate*	*High*
27	25	48

8 Conclusions

The present study aims to evaluate the added value from the new scientific developments, based in the concept of scientific management, in a business case in order to validate if these developments can effectively evaluate with a higher precision an initiative/project that aims value creation in an organisation. These developments emerged, as well, in the frame of the current digital transformation and in order to provide a more precise and sustained decision regarding the endeavour of a potential project development. Thus, it pretends to reply to the decision-makers' needs and decision analysis as a support-based information.

In this paper, it was evaluated the added value from the new scientific developments, comparing with the results of the business case evaluation from Pereira et al. (2021a), in a social institution in order to evaluate the benefits and cost estimation of the several activities in some services in a social institution using the same dataset. The conclusion obtained by Pereira et al. (2021a), which included the development of a specific framework using the SROI, have an overall project evaluation of the services benefits and cost estimation. It evaluated all the indicators although without measuring the contribution of each activity for the overall evaluation. Besides, it was not available any estimation, trends or forecasting. In the overall evaluation form the BC Tool of the project feasibility, it was indicated that the project is viable and the social association with the current services and activities will increase the level of efficiency of these services and provide a considerable increase of the provided services in terms of benefits.

On the other hand, the final evaluation of this business case and mention the last step (economic evaluation), which congregates information from all other steps, the level of risk was considered high compared with the other two classes although it was not a critical value, for instance, more 70% of probability of high risk. Thus, based in the remaining outputs it should be given the GO to the remaining process evaluation.

In short, analysing the two outputs provided from the BC Tool and the digital business case, it can be mentioned that the new algorithms provided a more comprehensive approach and project evaluation. The added value, in terms of benefits and cost estimation, using the several new scientific developments, provided a better overview regarding the activities contribution. The new models applied in the benefits and costs estimation, forecasted benefits and costs, correlation between the activities and the services, Bayesian probability of the difference value (the benefit and the cost being stable, increase or decrease) and the transition probabilities of risk analysis of the business case being turn this tool in a reliable and considerable added value in terms of

projects evaluation. It is undoubted that the developments described throughout this study provided a considerable benefit analysis for the social association as well as a more reliable view. For instance, in the step 'economic evaluation', there is a dubious decision regarding the project if it is a go/no go due to the similarity of the probabilities. The only way to validate these two outputs will be by collecting the results for the year 2020 and 2021 in order to have a clear decision. Thus, the assumption is clear, the scientific developments provided a more comprehensive view due to the ability to process this information in a repetitive, predictable and rigorous manner besides increase the level of efficiency of the project's evaluation.

In this paper, a critical lesson was gathered and obtained using these new developments. The lesson is that implemented changes, in a project evaluation method, using the scientific management philosophy, will effectively improve the business case if all processes, in each step, are aligned with the entire project evaluation and can be complementary in each single step. Therefore, the aim of these algorithms is to provide a comprehensive scientific method, which can provide an added value regarding the current and future project developments.

In terms of limitations, despite its important theoretical and practical contributions, this research suffers from some methodological limitations. First, the dataset is limited in terms of sample and only focused in one institution. Since it was a dataset already applied to other study, these two limitations cannot be overcome. Thus, future research might be obtained, namely from a major number of organisations in different industries and countries to test the generalisability of the results. Due to the sample limitations, some applied models could not be processed. For instance, this data limitation conditioned the outputs provided by the Bayesian probability and the Pearson correlation since the service 'elderly' had not enough data that can allow its calculation. Another limitation, it is the fact of some models are very specific and required a previous input (larger sample with continuous or discrete variables) in order to provide a valid input. The forecasting method is an example. Using only three years of data, the accuracy of the estimative is reduced since, in most of the cases, an estimate improves as the sample size increases (if representatives of the population). Nevertheless, this is just an expectation. Another important limitation for this paper, was the problem solving approach. This method could not be applied to the present study due to the fact that the dataset was not structure to that end. Thus, it was not considered. The importance of this output could have provide a different impact in this study or even a different validation. In the end, most of these new applied methods required a larger dataset in order to provide more accurate outputs. It is important to highlight, that the obtained data was design to be incorporated into the BC Tool while the digital business case aims a larger sample data and a questionnaires incorporating the problem solving approach, in order to provide a more precise output to support the decision-making process of a project evaluation.

9 Future work

Due to the current market demand, scientific developments and digital transformation, it is predicted two new steps in the digital business Case. Namely, the decision analysis and cost effectiveness analysis and times series forecasting system (based on the exponential moving average). These two new steps aim to increase the value creation and project evaluation as well to support the decision-making process. In the step 'benefits

estimation', it is foreseen the development and the implementation of the ordinary least square (OLS) method in order to estimate the unknown parameters in the equation integrated with the benefits and cost.

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