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Development of a managerial tool for prioritization and selection of portfolio projects using the Analytic Hierarchy Process methodology in software companies

Desenvolvimento de uma ferramenta gerencial de priorização e seleção de portfólio de projetos utilizando a metodologia Analytic Hierarchy Process em empresas de software

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Abstract: This study presents a managerial tool for prioritization and portfolio selection of software development projects using the methodology Analytic Hierarchy Process (AHP). The need for better results with scarce resources is a challenge for organizations to generate competitive advantage. The tool is structured according to the analysis of articles related to project prioritization and selection, portfolio management and the AHP methodology. The research approach was quantitative through an applied case study. The case was developed in a medium-sized software company in Santa Catarina, a leader in solutions for management excellence, provider of software and services for automation and business process improvement, regulatory compliance, and corporate governance. It has more than 2000 clients, of diverse sizes and lines of action. A committee was set up with managers and analysts to define the groups and criteria, and the application of a pilot of projects. There were opportunities to use this managerial tool to minimize power play, integration, information sharing, learning, commitment among decision makers and selection of strategically aligned projects.

Keywords: Portfolio management; Innovation; Prioritization; Project selection; AHP.

Resumo: *Este estudo apresenta uma ferramenta gerencial de priorização e seleção de portfólio de projetos de desenvolvimento de software utilizando a metodologia Analytic Hierarchy Process (AHP). A necessidade de melhores resultados com recursos escassos é um desafio às organizações para gerar vantagem competitiva. A ferramenta é estruturada de acordo com análise de artigos relacionados à priorização e seleção de projetos, gerenciamento de portfólio e a metodologia AHP. A abordagem de pesquisa foi quantitativa por meio de estudo de caso aplicado. O caso foi desenvolvido em empresa de desenvolvimento de software de médio porte, localizada em Santa Catarina, líder em soluções para excelência de gestão, fornecedora de softwares e serviços para automação e aprimoramento de processos de negócios, conformidade regulamentar e governança corporativa. Possui mais de 2000 clientes, de diversos tamanhos e ramos de atuação. Estruturou-se um comitê com gestores e analistas, para definição dos grupos e critérios, e aplicação de um piloto de projetos. Identificaram-se oportunidades de utilização desta ferramenta gerencial para minimizar o jogo de poder, integração, compartilhamento de informações, aprendizado, comprometimento entre os tomadores de decisão e seleção de projetos alinhados estratégicamente.*

Palavras-chave: *Gerenciamento de portfólio; Inovação; Priorização; Seleção de projetos; AHP.*

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1 Introduction

To remain competitive, the organization needs to select and invest in innovative projects (Carvalho et al., 2013; Pereira & Zilber, 2017), add value to the client and aligned with the strategy (Almeida & Duarte, 2011; Simplício et al., 2017), maximizing the result. In this way, the objective is to propose a managerial tool for prioritization and selection of projects for the development of software, using the Analytic Hierarchy Process (AHP) methodology, aligned with the exponential increase in the use of multi-criteria decision techniques (Zyoud & Fuchs-Hanusch, 2017).

The main factors in the implementation of corporate strategies are vision, management, human and financial resources (Cooper & Kleinschmidt, 2007; Gomes et al., 2012). The risks and uncertainties involved should be treated as relevant, since a misunderstanding will impact the final outcome.

The relationship between prioritized projects and business strategy is established by criteria that represent the organization's strategy for growth and long-term competitiveness (Cooper & Kleinschmidt, 2007). Due to the interaction between proposed projects, resources and risks, the distribution of investments is complex (Ghasemzadeh & Archer, 2000). The project portfolio consists of innovation projects, product improvements, product recovery, among others (Cooper et al., 1999).

Padovani et al. (2010) carried out prioritization and project selection studies using AHP in a chemical company, where they obtained an increase of assertiveness in project selection and maximization of portfolio results. The managerial tool of prioritization and portfolio selection of software projection using AHP is a way to extend applicability and verify if the results in other sectors also occur in this.

We sought detailed knowledge of hybrid portfolio selection methods, considering both quantitative and qualitative characteristics. With these premises, the AHP, developed by Saaty (1990), is used. The method allows the structuring of multiple criteria in hierarchy, evaluating the importance among criteria, comparing projects by criterion, and determining the classification of projects. From this classification, the projects will be selected, considering the resources available.

To evaluate this tool, the case study methodology is used. The study is carried out in a medium-sized national company of the sector of information technology and communication, located in Santa Catarina, developer of software and services. The characteristics of the projects refer to the implementation of new functionalities, improvement of ergonomics and usability, with development cycle of 3 months.

This article is structured in six sections, including the introduction. The next section presents the theoretical framework of portfolio management, methodologies and criteria used. The third section presents the methodological procedures used. The fourth section presents the managerial tool, considering the prioritization and selection of groups and criteria, and software proposed. Finally, we present results, discussions, and conclusions of the study.

2 Theoretical reference

The importance of portfolio management is highlighted by several authors, but the choice of "right projects" is more than a selection of projects (Cooper et al., 1999; Simplício et al., 2017), it involves an updating and revision process. Archer & Ghasemzadeh (1999) propose a project portfolio approach divided into five stages: pre-selection, individual analysis, screening, portfolio selection optimization, and portfolio adjustments.

In the process of selection of project portfolio, several methods are highlighted. The aproach ad hoc can be treated as a rough form of scoring model, or as an interactive selection, to the choice of projects (Archer & Ghasemzadeh, 1999). It is a method that power can define what will be selected.

Another method is financial, where profitability, internal rate of return or return on investment is determined, and projects are evaluated and ranked (Cooper et al., 1999). It is a method where the proposed projects are easily defined, but does not consider the risks and strategies of the organization.

The business strategy method, where the company strategy is the basis for the allocation of financial resources to different types of projects (Cooper et al., 1999). It is a method in which the strategy is defined, resources are established for different types of projects, and projects are ordered according to each strategy.

Another method is market research, where the strategic implications of portfolio selection are complex and involve factors internal and external to the organization, including the market and strengths and weaknesses. Decision makers assess the current position of the organization and where they want to be in the future. In this way, the project portfolio will be selected (Archer & Ghasemzadeh, 1999; Siddiqi, 2000). It is a complex and often not clearly understood method due to subjectivity, especially if the scenario is not adequately defined.

The scoring model is a project portfolio selection method, which utilizes few decision criteria to specify the suitability of the project. Scores are combined, and there may be different weights, to produce a measure of overall benefit for each project. One advantage is when adding or removing a project, you do not need to recalculate the other projects (Cooper et al., 1999; Luz et al., 2006). This method makes it possible to evaluate each project individually, and several projects can have the same score.

The bubble diagram or portfolio matrix is a flexible method that can be used as a strategic decision-making tool. It serves to prioritize and allocate resources between competing projects. It is based on graphical representations of the proposed projects, in two dimensions, such as the probability of success and expected economic value, allowing a representative combination of projects in the considered dimensions to be selected (Cooper et al., 1999; Ledoit & Wolf, 2003).

The comparative approach or multicriteria analysis allows for peer-to-peer comparison, where committee consensus is important. In this method, first the goal weights are determined, then the alternatives are compared based on their contributions to those objectives, and finally a set of project benefit measures are computed (Saaty, 1990). With projects organized on a comparative scale, the committee selects projects from the top of the list until the available resources are fully utilized (Padovani et al., 2010; Dutra et al., 2014). This technique considers quantitative and qualitative criteria. When a project is added or deleted from the list, the process must be repeated (Gupta et al., 2015; Kaiser et al., 2015; Neves & Camanho, 2015).

Finally, the optimization model selects from the list of candidate projects a set that provides the maximum benefit. It is based on mathematical programming, supporting the process of optimization and inclusion of project interactions, such as: resource dependences and constraints or technical and market interactions (Anagnostopoulos & Mamanis, 2010; Kremmel et al., 2011). Optimization models can be used with other approaches that calculate benefit values (Solak et al., 2010; Daneva et al., 2013).

Chart 1 presents a summary of the methods raised with the respective authors referenced in chronological order.

It is identified an increase in the number of authors with studies involving a multi-criteria decision analysis technique (Zyoud & Fuchs-Hanusch, 2017), applied in sectors such as: chemical, electrical energy distributor, teaching and research institution, oil and gas, automotive, marine and construction industries. Among the several methods that use multiple criteria are: Analytic Hierarchy Process (AHP), Élimination Et Choix Traduisant la Réalité (ELECTRE) and the Multiaplicative AHP (MAHP). Among the methods collected, this article focuses on comparative approaches, where AHP fits. The decision to carry out this study by the multi-criteria approach is due to the number of authors studying this method (Zyoud & Fuchs-Hanusch, 2017), as well as the structuring of criteria and the involvement of responsible individuals from different areas for evaluation. Criteria used by several methods are presented in Chart 2, highlighting Cooper's work et al. (1999), who verified a large number of companies using financial criteria to select the projects, and strategic criteria, such as: risks, competitive advantage, capacity of resources and urgency. On the other hand, studies by Dutra et al. (2014) show the most frequent use of financial cost criteria and the lower use of criteria related to technical difficulty.

Chart 1. Portfolio selection methodologies.

Methods	Saaty (1990)	Archer & Ghasemzadeh (1999)	Cooper et al. (1999)	Ghasemzadeh & Archer (2000)	Siddiqi (2000)	Ledoit & Wolf (2003)	Luz et al. (2006)	Anagnostopoulos & Mamanis (2010)	Padovani et al. (2010)	Solak et al. (2010)	Kremmel et al. (2011)	Daneva et al. (2013)	Dutra et al. (2014)	Gupta et al. (2015)	Kaiser et al. (2015)	Neves & Camanho (2015)	Tavana et al. (2015)	Mello et al. (2017)	Ribeiro & Alves (2017)	Simplício et al. (2017)	Total
Approach ad hoc		X																			1
Financial methods		X	X																		2
Business strategy methods		X	X																		2
Market research		X			X																2
Models of scores			X				X														2
Bubble diagram or portfolio matrices			X			X															2
Comparative approaches or multicriteria analysis	X			X					X				X	X	X	X	X	X	X	X	11
Optimization models								X		X	X	X									4

Chart 2. Project selection criteria.

Criteria	Cooper et al. (1999)	Luz et al. (2006)	Padovani et al. (2010)	Rahmani et al. (2012)	Carvalho et al. (2013)	Dutra et al. (2014)	Purnus & Bodea (2014)	Escobar (2015)	Reginaldo (2015)	Ferreira et al. (2016)	Total
Strategic alignment				X					X		2
Technical criteria				X		X	X			X	4
Cost	X	X	X	X		X		X			6
Availability	X	X									2
Level of innovation			X			X					2
Uncertainties involved			X		X	X					3
Process improvement				X					X		2
Cost-benefit ratio							X	X			2
Profitability								X	X		2
Return on investment	X						X				2
Risk	X			X	X		X	X			5
Internal rate of return	X						X				2
Net present value (NPV)	X			X			X				3

According to Padovani et al. (2010), the simulation of different scenarios, hierarchy of decision criteria, allows managers an efficient decision support process for the treatment of constraints. These restrictions are not only related to resources, but also to financial and supply aspects (Purnus & Bodea, 2014).

The identification of decision criteria for project selection is endowed with different criteria according to the type of project and organization (Castro & Carvalho, 2010; Maccari et al., 2015). For Carvalho et al. (2013), the criteria that stand out are: market potential, economic and financial viability, risks and uncertainties. Due to working in a dynamic market (Gava et al., 2015), of new technologies in hardware and software, the situation is more challenging if compared to projects in other industry sectors (Roratto & Dias, 2012). Among the studies surveyed, the most prominent criteria in the development of software are: cost, risk, technical and uncertainties.

The selection of a project should consider the interdependence between projects (Nascimento, 2013), since there will be selected projects to be executed together with others, which may not have been considered. To consider these situations described in the various studies, this article proposes the use of several criteria so that the prioritization and selection process is transparent and balanced. In the comparative approach, the AHP technique was chosen because it allows pair-to-pair, hybrid comparison and it is "friendly", in addition to a greater number of publications.

In studies carried out in a chemical company by Padovani et al. (2010), it was observed the ease of structuring the decision-making process by the elaboration of a hierarchy of decision criteria during meetings with the decision-makers. The use of the model minimizes the risk of the decision maker falling into traps, since the discussion allows participants to learn and to obtain consensus in the definition of criteria and voting. The managerial tool minimizes problems of power play, allows an integration, information sharing, commitment among decision makers, and team learning (Ribeiro & Alves, 2017).

The AHP is a logical multi-criteria decision-making technique that allows decision makers to model a complex problem based on mathematics and psychology (Saaty, 1990), helping in the choice and justification. It is defined as an approach to decision making that involves criteria structured in hierarchy. The application of AHP to a decision problem involves the following steps:

a) Step 1: Structuring the decision problem in a hierarchical model, including the decomposition of the problem into elements according to their common characteristics and the formation of a hierarchical model with different levels. The AHP model has three levels that are: goal, criteria and alternatives;

b) Step 2: Carry out the peer-to-peer comparisons and fill in the matrix, where the elements of a level are compared with respect to a specific element at the immediate top level. This comparison allows you to define the factor, which will be between 1 and 9. Typically, an element receiving higher ranking is seen as higher in importance compared to another that receives a lower rank. A consistency rate of less than 0.1 is acceptable because human judgments need not be consistent, and there may be inconsistencies introduced because of the nature of the scale used. The ability to identify inconsistent judgments by calculating the consistency ratio is considered one of the strengths of the AHP.

Among the five stages presented by Archer & Ghasemzadeh (1999), the focus of this article will be the screening.

3 Methodological procedures

This section describes the research method adopted and procedures to ensure reproducibility of the study. It is characterized by a quantitative approach, through a case study, using the exploratory and applied strategy. The motivations for the use of the AHP were the ease that it provides in the measurement of the problem variables and the capacity to structure the problem in hierarchy, making possible the elaboration of a managerial tool of prioritization and selection of projects for a development company software, comprising the following steps:

a) Identification of criteria: documental research identified the criteria already used in other studies, but adequate to the focus sector. For a clearer definition, two levels were defined, the first called group and the second criterion. In this way the criteria could be grouped, to avoid conflicts of understanding, by the committee composed of representatives of the organization;

b) Application of the AHP to the criteria: AHP priority calculation based on the committee's analysis, using a previously configured spreadsheet for each stage. First the groups were organized to be compared and then the criteria;

c) Project definition: internal and external suggestions were grouped by similarity and related characteristics;

d) Application of the AHP to the criteria: AHP priority calculation based on the committee's analysis, using a previously configured spreadsheet for each stage. The projects were compared for each criteria;

e) Prioritization and selection of projects: based on the factors calculated, carried out the descending order, where near the top of the list are the most important.

During the process of evaluating the criteria and projects, relevant facts of the process were observed, such as the importance of the meaning of each criterion and knowledge of the projects, so that the committee could carry out a better evaluation. The evaluation of the managerial tool was carried out between June and December 2016, through a case study, in a medium-sized software company.

4 Managerial tool for prioritization and portfolio selection of *software* projects

The definition of projects that are part of a portfolio should be carefully evaluated. The use of adequately defined and strategy-aligned criteria allows the committee to evaluate projects from various angles. The comparative approach will be used to define the project portfolio. Periodic reviews are made to evaluate project performance and strategy alignment. In the case of review of the strategic planning, the portfolio of projects is re-evaluated.

The managerial tool is divided into four phases, which make up the framework, presented in Figure 1.

In the initial phase groups and criteria are defined, and factors are evaluated. These groups and criteria aim to consider the various ways of evaluating projects aligned with strategies. The second phase defines the projects and the evaluation of the factors. The pre-selection of projects occurs, considering projects with minimal characteristics. After the selection of the projects, the comparisons are made to obtain the factors. In the third phase are selected the projects with the best factors to compose the portfolio according to resource constraints. In the fourth phase the monitoring and evaluation of the projects takes place. Framework with the detailed phases are shown in Figures 2 to 5, which are described below.

In step 1 we define groups (target level) and criteria (criterion level), performed by a committee composed of managers, and defined according to the unfolding of strategic planning. To verify the feasibility of project selection criteria in a software company, Chart 3 presents the proposed criteria to consider. The groups and criteria applied are presented in Chart 4, in the Results and Discussions section. The number of criteria considered may vary according to committee and organization ratings.

In step 2, the factor of each group is calculated, presented in the group column of Chart 3. It is necessary to create a square order decision matrix n in which n represents the number of groups analyzed. The committee

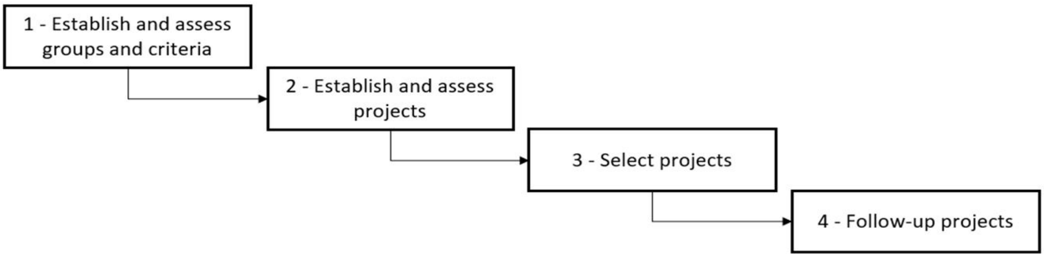

Figure 1. Framework of the managerial tool.

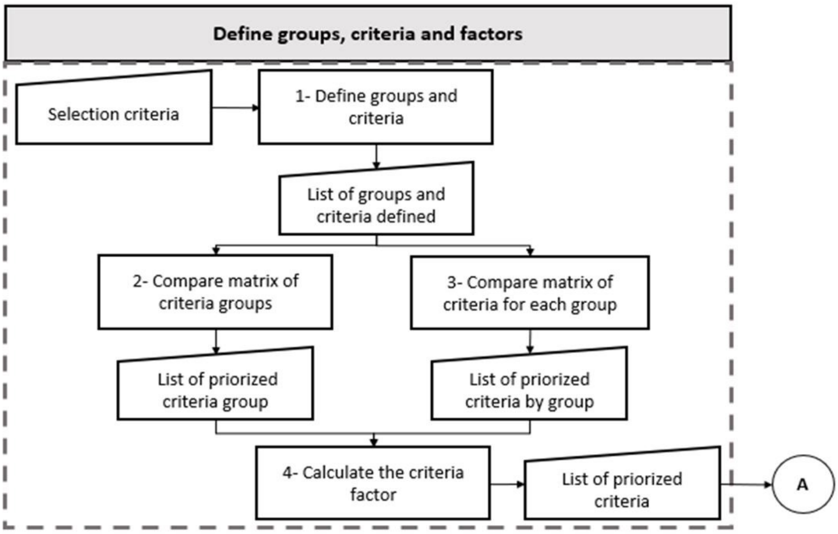

Figure 2. Managerial tool – Phase 1.

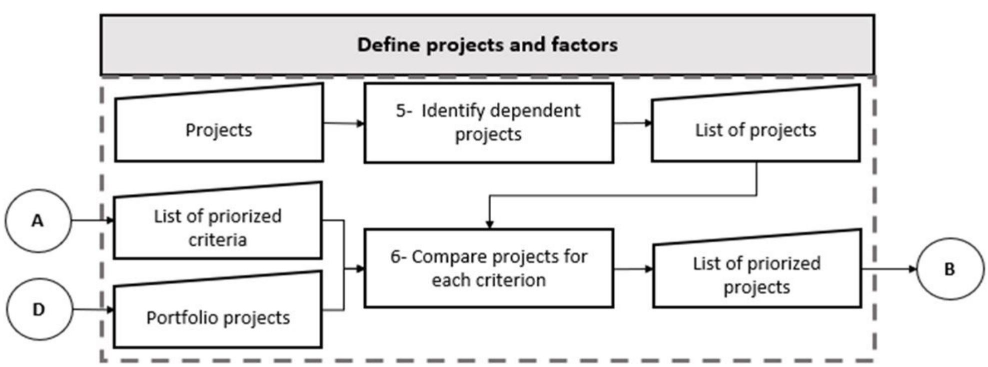

Figure 3. Managerial tool – Phase 2.

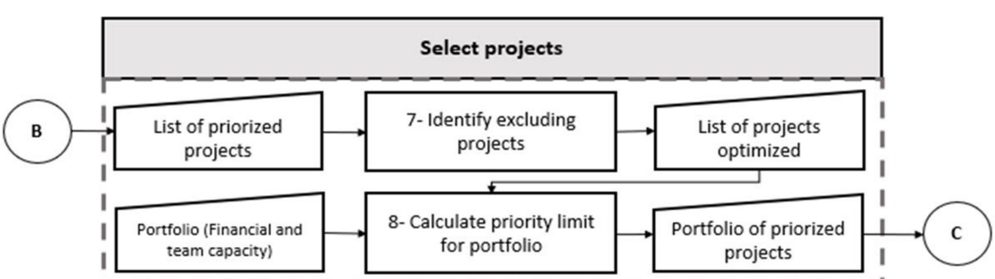

Figure 4. Managerial tool – Phase 3.

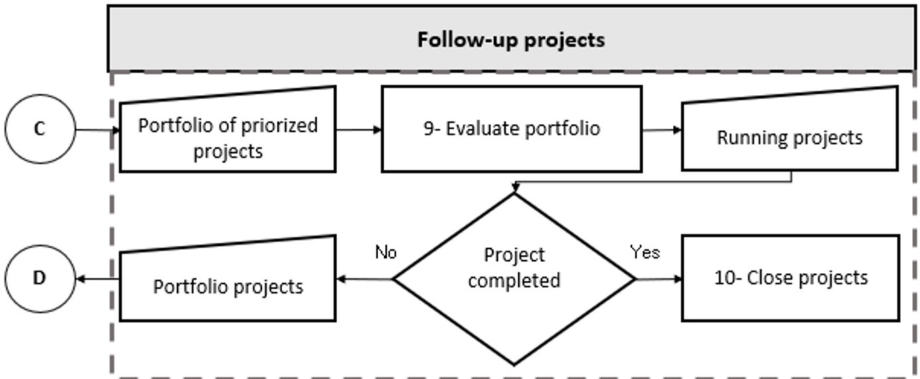

Figure 5. Managerial tool – Phase 4.

Chart 3. Groups and selection criteria.

Group	Selection criterion	Group	Selection criterion
Group 1	Criterion 1.1 ... Criterion 1.n	...	...
Group 2	Criterion 2.1 ... Criterion 2.n	Group n	Criteria n.1 ... Criterion n.n

Chart 4. Groups and selection criteria for software projects.

Group	Selection criterion	Group	Selection criterion
Strategic benefits	Strategic alignment High management support Community benefits Competitive advantage	Technical difficulty	Technical criteria Scope of development Degree of innovation Technological risk
Business benefit	Responding to clients' needs Process improvement Market potential / Billing Market risk	Finance costs	Cost of the project Return on investment Uncertainties involved Net present value

that will evaluate the elements of the matrix is represented by a predefined scale, the fundamental scale of Saaty, presented in Table 1, with the numerical and reciprocal values. The decision-making will do the $(n*(n-1))/2$ peer-to-peer comparisons. The matrix is constructed by comparing the groups and using the Saaty scale, shown in Table 2. The comparison matrix of the applied groups are presented in the Results and Discussions section.

To perform the interpretation and define the weights, it is necessary to normalize the comparison matrix. Normalization is performed by dividing the value of each row / column of the table by the total value of the column (Table 3).

Next, the data inconsistency rate is calculated to determine if the committee was consistent in its choices. The calculation considers the total of each column of Table 2, multiplied by the total average of each row, presented in Table 3. The result of each of the multiplications is summed, the calculation of which is shown in Table 4.

For the elements considered, the consistency index (CI) is calculated according to Equation 1.

$$CI = \frac{VP - n}{n - 1} \tag{1}$$

being n quantity of evaluated elements.

In order to verify if the consistency index result is adequate, the consistency ratio (CR), determined by the ratio between the consistency index (CI) and the random consistency index (RI), given by Equation 2.

$$CR = \frac{CI}{RI} \langle 10 \sim 10\% \tag{2}$$

The random consistency index (RI) is fixed and is based on the number of alternatives n evaluated, according to Table 5. The matrix will be considered consistent if the result is less than 10%, otherwise the comparisons should be redone.

Step 3 considers the criteria of each group, presented in Table 3, whose objective is to obtain the factor of each criterion. The comparison follows the same principle of step 2, including for the calculation of the consistency ratio. Structure n matrices, one for each group, considering the criteria of each group separately.

The purpose of step 4 is to calculate the factor of each criterion, considering the factor obtained from the group to which it belongs. This calculation is the multiplication of the factor of the group obtained in step 2 by the criterion factor obtained in step 3.

Table 1. Saaty's fundamental scale.

Scale	Numerical rating	Reciprocal
Equally importance	1	1
Moderate importance	3	1/3
Strongly importance	5	1/5
Very strongly importance	7	1/7
Extremely importance	9	1/9

Source: Adapted from Saaty (1990).

Table 2. Comparison matrix.

	Element 1	Element 2	...	Element n
Element 1	1	A12	...	A1n
Element 2	1 / A12	1	...	A2n
...	...	...	...	...
Element n	1 / A1n	1 / A2n	...	1
Total	$\sum(C1)$	$\sum(C2)$	...	$\sum(Cn)$

The result represents the influence factor of each criterion in the general scenario. Steps 1, 2, 3 and 4 were separated to characterize the actions performed, being in accordance with the AHP method (Saaty, 1990).

In step 5, the proposed projects (alternative level) are identified and grouped that have common requirements and must be implemented sequentially. This evaluation stage minimizes situations of projects that have prerequisites that should already be implemented. If this stage were not considered, it would be necessary to define a network of project precedence, because projects selected, would only be executed if others with minor importance or not selected were executed previously. Step 5 is completed with the selection of n more important projects.

In the proposed scenario the execution of step 6 is composed of n square decision matrices, one for each criterion presented in Chart 3. Each matrix will be composed of the number of projects mapped in step 5. The objective is to obtain the factor of each project, through the paired comparison. The comparison follows the same principle presented in steps 2 and 3. To finalize step 6, the factors obtained from each project in each criterion will be summed to obtain the actual factor of each project.

Step 7 consists of evaluating projects with excluding relationships. Excludent relationships are considered, situations in which one project has one objective and the other project has an antagonistic goal. Should this occur, projects of higher priority should be retained, while those of lower priority should be disregarded. The end result of this step is the optimized project list.

In step 8 the selection of the best classified projects is performed, through the balance of available

Table 3. Comparison matrix after normalization.

	Element 1	Element 2	...	Element n	Total Average
Element 1	$1/\sum(C1)$	$A12/\sum(C2)$	...	$A1n/\sum(Cn)$	$\sum(LC1)/n$
Element 2	$(1/A12)/\sum(C1)$	$1/\sum(C2)$	...	$A2n/\sum(Cn)$	$\sum(LC2)/n$
...	...	...	...	...	...
Element n	$(1/A1n)/\sum(C1)$	$(1/A2n)/\sum(C2)$	...	$Ann/\sum(Cn)$	$\sum(LCn)/n$

Table 4. Calculation of the principal value.

Factor	$\sum(LC1)/n$	$\sum(LC2)/n$	...	$\sum(LCn)/n$
Total	$\sum(C1)$	$\sum(C2)$	...	$\sum(Cn)$
Main Value (VP)	$[(\sum(LC1)/n*\sum(C1))+(\sum(LC2)/n*\sum(C2))+...+(\sum(LCn)/n*\sum(Cn))$			

Source: Adapted from Saaty (1990).

Table 5. Random consistency index.

N	1	2	3	4	5	6	7	8	9	10
RI	0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49

Source: Saaty (1990).

resources, to maximize the portfolio results. Step 9 is characterized by monitoring the performance of portfolio projects, using indicators defined by the company. As a suggestion, value-added analysis is used to identify whether the project is within the planned, delayed or advanced, for term and cost. In this step it is verified whether the project was executed completely or not. If it has been completely executed, it will be closed, following the process adopted by the organization, represented by step 10.

5 Results and discussions

The company studied develops software projects and has approximately 200 employees, being classified as medium-sized, according to BNDES (2017). The company maintains management focused on strategic and budget planning, with ISO 9001 certification.

The committee was structured with representatives from marketing, commercial, customer service and product development, which are the main areas involved in identification, prioritization, selection, development and delivery. Everyone involved has a degree in technology and at least ten years of experience in the industry.

The demands presented refer to customer suggestions, new customer opportunities, needs identified by the company and competitors' assessment. These demands have the characteristics of expanding the use of the system, new forms of application, and requirements that competitors already offer and that the solution does not meet. The projects considered in this study were previously evaluated for the clarity of the need, added value and alignment of the strategies. The development cycle is three months and the projects considered are of medium and large size.

The criteria chosen are based on studies carried out in the literature presented in Chart 2 and suitable for software development companies, through a consensus so that subjectivity did not hinder understanding during the evaluation, and inadequate results were obtained. Criteria considered important by the evaluation committee were also included, the results of which are presented in Chart 4. Because there is no rule to define the exact number of criteria, a number is defined so that projects are evaluated in a balanced way. This study is based on four groups: "strategy", "commercial", "technical" and "financial". For each group four criteria are considered, considering that the comparisons consider a representative part of criteria, providing balanced analysis and reduction of personal influence.

As of Chart 4 shows the comparison between the groups, where the comparison result is recorded in the matrix presented in Table 6. In one comparison example, the committee agreed on "business benefit" of moderate importance (3) in relation to "finance costs". In the reverse comparison, the reciprocal value (1/3) is recorded. This same procedure was performed for the other comparisons between the groups. After normalization and performed calculations, as described in section 4, the results are presented in Table 7. From these results the importance of each group is identified.

With the factors of each group, the data inconsistency rate is calculated to verify the consistency of the results obtained. The comparison of the criteria by group follows the one described in the proposal, where Tables 8 to 11 present the factors evaluated by the committee.

According to the standard procedure presented in the managerial tool, the normalization is done by comparing the consistency ratio and applying the factor of the group in each criterion to obtain the factor of each criterion, which are presented in Table 12, where the step is completed. At this moment the criteria of major and minor importance are identified.

When selecting the projects, compare for each criterion and consolidate the information, the factors of each project are presented, shown in Table 13.

Table 6. Comparative group matrix.

	Business benefit	Strategic benefits	Finance costs	Technical difficulty
Business benefit	1	1/3	3	5
Strategic benefits	3	1	7	7
Finance costs	1/3	1/7	1	3
Technical difficulty	1/5	1/7	1/3	1
Total	4.5333	1.6190	11.3333	16.0000

Table 7. Comparative matrix of groups with factor.

Group	Calculation	Factor
Business benefit	= (0.2206 + 0.2059 + 0.2647 + 0.3125) / 4	0.2509
Strategic benefits	= (0.6618 + 0.6176 + 0.6176 + 0.4375) / 4	0.5836
Finance costs	= (0.0735 + 0.0882 + 0.0882 + 0.1875) / 4	0.1094
Technical difficulty	= (0.0441 + 0.0882 + 0.0294 + 0.0625) / 4	0.0561

Table 8. Comparative matrix of business benefits group criteria.

	Responding to clients' needs	Process improvement	Market potential / Billing	Market risk
Responding to clients' needs	1	5	3	5
Process improvement	1/5	1	1/3	1/3
Market potential / Billing	1/3	3	1	3
Market risk	1/5	3	1/3	1
Total	1.7333	12.0000	4.6667	9.3333

Table 9. Comparative matrix of estrategic benefits group criteria.

	Strategic alignment	Support from top management	Community benefits	Competitive advantage
Strategic alignment	1	9	5	5
Support from top management	1/9	1	1/3	1/3
Community benefits	1/5	3	1	3
Competitive advantage	1/5	3	1/3	1
Total	1.5111	16.0000	6.6667	9.3333

Table 10. Comparative matrix of financial cost group criteria.

	Project cost	Return on investment	Uncertainties involved	Net present value
Project cost	1	1/3	1/5	1/3
Return on investment	3	1	1/3	1/3
Uncertainties involved	5	3	1	3
Net present value	3	3	1/3	1
Total	12.0000	7.3333	1.8667	4.6667

Table 11. Comparative matrix of technical difficulty group criteria.

	Technical criteria	Scope of development	Level of innovation	Technological risk
Technical criteria	1	1/3	1/3	1/9
Scope of development	3	1	1/3	1/5
Level of innovation	3	3	1	1/5
Technological risk	9	5	5	1
Total	16.0000	9.3333	6.6667	1.5111

Table 12. Consolidation matrix with the criteria by group.

Group	Criteria	Factor
Business benefit	Responding to clients' needs	0.1363
	Process improvement	0.0765
	Market potential / Billing	0.2445
	Market risk	0.1360
Strategic benefits	Strategic alignment	0.3662
	Support from top management	0.0324
	Community benefits	0.1155
	Competitive advantage	0.0696
Finance costs	Project cost	0.0084
	Return on investment	0.0174
	Uncertainties involved	0.0584
	Net present value	0.0288
Technical difficulty	Technical criteria	0.0031
	Scope of development	0.0067
	Level of innovation	0.0111
	Technological risk	0.0352

Table 13. Projects with consolidated factors.

Project	Factor	Project	Factor
Project P1	0.0876	Project P6	0.0432
Project P2	0.0785	Project P7	0.0448
Project P3	0.1380	Project P8	0.0274
Project P4	0.1519	Project P9	0.0639
Project P5	0.2963	Project P10	0.0597

After completing the steps, it is concluded that the projects P5, P4 and P3 are the most important. Before performing the steps of this managerial tool, a preliminary evaluation was carried out to identify the most important projects. The preliminary evaluation was influenced by external factors such as hierarchy, client and personal perception. Comparing the two forms, it is understood that this managerial tool allows a more detailed and impersonal evaluation. Due to finite resources, only the P5, P4 and P3 projects were selected. The remaining projects may be selected, provided that the projects initially selected are executed and closed, or according to changes in the scenario initially proposed, whether strategic or resource capacity.

6 Conclusion

The objective of this study was to present a managerial tool for prioritizing and selecting projects for the development of software using the AHP methodology in order to balance the project portfolio. Evidence was sought in a case study in a medium-sized software development company, which has been active in the sector since 1995, in the State of Santa Catarina.

It was observed in this study, the importance in the definition of groups and criteria aligned to the company's strategy, and may vary for other companies in the sector. This work contributed to simplify, standardize and improve the quality of the decision-making process in the area of software development, with the involvement of representatives of important areas composing the committee. Because the AHP method has already been successfully applied in other industry sectors, the expectation initially anticipated has been confirmed.

The comparison between the projects, for each criterion, allowed the identification of the most important projects. The proper evaluation of the groups and criteria was paramount, since the factors impact on the results of each project. When doing the comparison between projects for one criterion, not necessarily for another criterion the result was the same, this results from the evaluation consider different characteristics and factors.

The importance of using this managerial tool for software development companies, allows projects to be compared against the same criteria, either qualitative or quantitative. This tool allows to minimize the power game, allows the integration, information sharing, learning and the commitment among the decision makers. The applied management tool can be expanded to other software development companies, increasing the size of the evaluation sample, both in relation to the characteristics of projects and in relation to the number of criteria. In this way the impact of this tool in new scenarios is verified, corroborating with the results obtained in this study.

To improve the managerial tool, one option is to reduce the number of criteria, verifying that the considered projects will be impacted with the new scenario. Another option is to increase the number of projects, but the evaluation effort will increase due to the increase in the number of comparisons and calculations required. It is recommended the selection of medium and large projects due to the evaluation effort. Finally, the scope was for the medium-sized software development company, surveys that identify similar situations or conditions would increase the validity of the tool and adjustments according to the new considerations.

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