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DECISION-MAKING MODELS APPLIED TO IT PROJECT SELECTION

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Dissertation

presented as partial requirement for obtaining the Master Degree Program in Information Management

NOVA Information Management School
Instituto Superior de Estatística e Gestão de Informação

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DECISION-MAKING MODELS APPLIED

TO IT PROJECT SELECTION

By

Gil Salvador Peso

Master Thesis presented as partial requirement for obtaining the Master's degree in Information Management, with a specialization in Information Systems and Technologies Management

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ABSTRACT

IT project investments: how can we identify the best project to invest? To invest means to spend resources with the intention of future benefits. Can this evaluation be made in a sustained way that minimizes the failure of a wrong pick and therefore someway to be assure of those benefits?

The aim of the study is to build a decision-making tool, based on existing multipurpose ones and to perfect it to the IT Project Portfolio reality, with an in-depth project analysis, valuing its tangible and intangibles characteristics to facilitate the organization board or decision makers.

Following an inductive based thinking, real decision-making matrixes are to be dissected to establish a future generalization in form of a new tool to apply to a specific scenario. A mixed strategy (quantitative strategy to the establishment of cause-effect relations and qualitative to understand intangible factors associated to the IT projects) will be adopted.

KEYWORDS

Decision-making Models; Intangible; Portfolio; IT Project Selection.

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LIST OF ABBREVIATIONS AND ACRONYMS

AHP	Analytic Hierarchy Process
AOR	Area of Responsibility
BCR	Benefit-Cost Ratio
BPMN	Business Process Model and Notation
CA	Competitive Advantage
COPRAS	Complex Proportional Assessment
COTS	Commercial off the Shelf
ELECTRE	Elimination and Choice Expressing the Reality
EVA	Economic Value Added
GMS	Gil Malta Santos Enterprise
IRR	Internal Rate of Return
HR	Human Resources
IT	Information Technologies
MCDM	Multi Criteria Decision Making
MOU	Memorandum of Understanding
M&A	Merges and Acquisitions
NOPAT	Net operating profit after taxes
NPV	Net Present Value
PPM	Project Portfolio Management
PMBOK	Project Management Institute Book of Knowledge
PMO	Project Management Office
PV	Present Value

ROI	Return on Investment
R&D	Research and Development
SCP	Single Clinical Post
SME	Subject Matter Expert
SMS	School Management System
TCO	Total Cost of Ownership
TODIM	*Tomada de Decisão Interativa Multicriterio*
TOPSIS	Technique for Order of Preference by Similarity to Ideal Solution
VIKOR	VIseKriterijumska Optimizacija I Kompromisno Resenje
VUCA	Volatile, Uncertain, Complex and Ambiguity
WACC	Weighted average cost of capital

1. INTRODUCTION

1.1 BACKGROUND AND PROBLEM IDENTIFICATION

In a global demanding economy, characterized by competitive markets and the struggle to thrive, organizations need to up their strategies and competitiveness. The well acronym VUCA stands for Volatile, Uncertain, Complex and Ambiguity, Cuevas et al. (2021, p.41), is a simple and basic acronym to translate the wild business world that we live in, and when taken together shows its difficult nature: Volatile (world in a constant change, for example a sudden change of government on a given country; commodities rising prices; or a trend that falls into oblivion); Uncertain (because we are in a volatile world, uncertainty is always present); Complex (for instance the growing complexity of technology use and development and how to apply it) and finally ambiguity (translates the lack of clarity and the difficulty of understanding clearly what the situation is).

Organizations should apply their capital carefully, restrained by obvious limitations: resources. When new projects to invest appear, the decision of its adoption should follow basic principles such as business and stakeholders' strategic alignment, resources economy, leverage, and positive business competitiveness enhancement that impacts not only in minimizing a possible negative consequence of an unsuccessful choice but an assurance and a guarantee that the chosen project to invest is the wright one. Equally, the same principles applied to "Projects" in general terms are applied to IT Projects. Though facing a technological area, project management bases are included in IT Project Management. To achieve that strategic and competitive enhancement, project solutions must be identified and chosen based on rigorous criteria. In the 90's for instance, the trend of choosing commercial off-the-shelf (COTS) IT solutions packages pushed companies towards generic business models and therefore countless ways to diverge from a stakeholder point of view (Cameron, 2011, p.41).

Resource management is mandatory, as it is a judicious way to choose when, where and how to invest. Meaning that in face of several projects in a given portfolio, only one or a few can be selected to keep organizations in the thriving path. If Project Management can be identified as the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements (Project Management Institute 2017, p.10), Project portfolio management (PPM) is "…a set of business practices that brings the world of projects into tight integration with other business operations. It brings projects into harmony with the strategies, resources, and executive oversight of the enterprise and provides the structure and processes for project portfolio governance." (Levine, 2005, p.1), or "Project portfolio management is concerned with managing groups of projects, programs, and operational activities … that

compete for scarce resources and that are conducted to achieve strategic business objectives"(Curlee, 2014, p.12).

The project portfolio concept backs to 1952, developed by Markowitz in its Modern Portfolio Theory (Markowitz, 2007), in which it starts a paradigm of a portfolio management opposed to a single project analysis. Mathematically Markowitz demonstrates the advantages of centralized management, among other factors, in how several projects can simultaneously contribute to a given investment and that the comparative basis brought about by diversity allows for gains associated with that same comparison.

Regarding to IT solutions, for what purposes would it serve an organization to have a state-of-the art solution if only 20% of that solution is explored? Occasionally organizations have a huge portfolio of alleged "wright ones" not all can be implemented. According to (Siddhartha Sampath , (2013, p.2) "The difficulty in product portfolio selection is compounded by the fact that not all projects for consideration in the process are at the same stage of their life cycle.". This lack of project maturity may have consequences born from unmatured forecast or revenue.

According to Davis (2013, p. 48), a big part of planning, which prevents runaway projects, is determining the details of the solution and context. Those are how the project team will deliver the best solution for the business problem, and how this solution fits into the surrounding business architecture.

So, one of the actual problem lays in IT projects complexity per se are difficult to analyse, highly technical (though checked by SME's) to critically inform the organization board of its liability, and its advantages among other projects in the portfolio. It requires technical knowledge to be able to indicate a good IT project to invest in, a project that will bring business success and profit. Do these experts look to the big picture when an IT project is evaluated? A word: Intangibles. The accounting of the intangibles associated to an IT project is not always made, with the intangibles dully appreciated, dully evaluated. It is a process that consumes enormous amount of time. Facing all these variables (vuca, organizations global competitiveness, sustainability, business complexity) …, what about a tool that could assist and ease the choice of future investments? A decision-making tool that would score an IT project, taking in consideration and account its tangible and intangible characteristics, to decide about its viability to later be presented to a board, a stakeholder, to invest?

1.2 MOTIVATION

This study revest itself of a huge importance. It is well known that the appraisal of an IT project is no easy task. Despite that the scenario of financial restraints is always present, the evaluation of a project encompasses variables that exceeds the simple fact that project A has a bigger financial cost than project B. The decision-making model to propose is a framework with different chapters, each one regarding a specific concurrent area of interest, that bond into an outcome that deliver a readable end quantifiable data to be compared and interpreted to support the final decision.

In an IT portfolio context, where several IT projects can be selected for investment, this analysis allows the identification of the opportunity cost. This concept translates in this study the loss of choosing one project to the detriment of another: if it is easy to measure it financially, what is the intangible opportunity cost of HR motivation loss or to a product brand or to the company from choosing project A and not project B?

1.3 AIM

The purpose of this of study is to develop a decision-making model to simplify, ease and help responsible actors in the decision-making process to conduct the process of decision and choosing IT projects to invest, in organizations that need to stand their businesses facing several investments project options on a limit and in-doors competitive resource context.

The research goal of the thesis should be to establish a decision-making model, based on existing multi-criteria decision models and apply it to IT portfolio project selection considering each project tangible and intangibles characteristics. To accomplish the goal the following objectives were defined and limited to:

- Identify reference decision-making models.
- Identify common valued tangible and intangible IT project characteristics.
- Build a decision-making model to apply to IT project selection, encompassing intangibles identification, assessment, and valuation.

1.4 RESEARCH QUESTIONS

Three main questions guide the study towards their answer:

1. Which decision-making model could serve as a basis to the study goal?
2. What are the main IT project characteristics, and which are to be highlighted when choosing an IT Project to invest from the portfolio?
3. Can intangibles associated to an IT project be identified and incorporated in a new decision-making model to help organizations to choose IT projects to invest?

1.5 STUDY RELEVANCE AND IMPORTANCE

Bigger the IT projects (involving more technology, more cost, more people…), more complex they are and harder to choose. It worsens if we must choose one in a basket, a portfolio with two, three or more. All projects laying on a portfolio may look feasible and profitable. Sometimes the establishment of the priority is made intuitively, unreasonably, rapidly. Whether is derailed from markets or stakeholders' pressure or the assumption that implement a new project is better that to implement none. A cared decision would allow an improved positive impact in organizations, less project investments failure. According to (James, 2019, p. abstract), only 39 percent of projects today are successful in adding value to the product and the organization investing in the project

How important would it be if there was a tool in the organizations to help an easier, sustained, and reasonable choice of an IT project?

The study will expose existing decision-making tools and transpose them to the IT project selection area of study. Differently of existing ones, they will have to take in consideration the tangibles factors of an IT project, but important and not always taken in consideration, the intangibles ones.

Intangibles? Do they have value? Are they hidden in projects? They are. So, a rephrase the previous question: How important would it be if there was a tool in the organizations to help an easier, sustained, and reasonable choice of an IT project, taking in consideration its intangibles characteristics? To have a comprehensive framework that could allow organizations responsible actors to ease decision-making process, it is what the study aims.

Organizations would profit with such a tool. Scientifically this new comprehensive tool could be openly shared and further developed is needed. It could derail from IT to other scientific areas.

2. THESIS METHODOLOGY AND LITERATURE REVIEW STRATEGY

To achieve the goal of this study it will be followed a methodological path divided in three distinct phases: exploration phase, development phase and conclusive phase. Each phase is divided by specific steps as identified in figure 1., that will be able to reach the proposed specific goals.

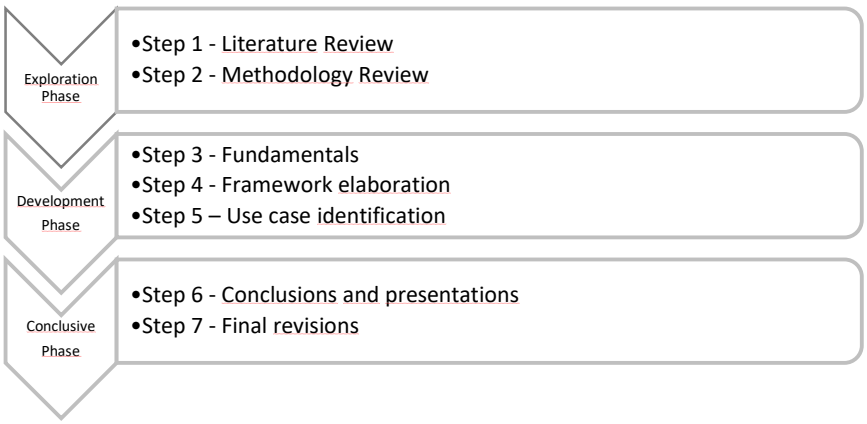

Figure 1 - Methodology outline

As a strategy, it was selected a theoretical review of literature. The scope of the topic is narrowed, and the process of library selection starts. It is in the exploration phase, where the theoretical basis will be grounded. As depicted in figure.2, it starts with some considerations on the identification of IT projects main valued characteristics (tangibles and intangibles), an overview of IT project portfolio context and its value, and finally the look over decision-making models.

Following the library reading, the development phase, where an evaluation is made, organizing the selected literature, and developing subtopics. Data will be collected, treated, analysed, and presented in a schematic approach, gathering all the review of literature evidence to produce de artefact.

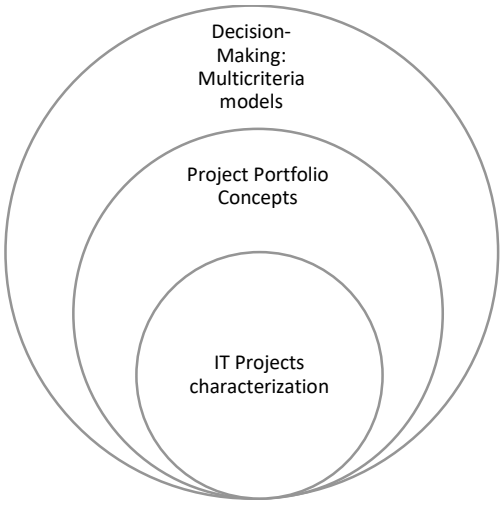

Figure 2 - Data collection model

In the conclusive phase, it will be identified the principal conclusions obtained, the identified limitations to this approach, the contribution of the work for the knowledge, and future studies recommendations. After delivering the first complete version to discussion, it will be carried out all necessary revisions to the final delivery.

This study follows an inductive rational basis in the sense that is starts from a mental operation that observes particular facts to, through their association, establish generalizations that appear to formulate a law or theory (Barreiros et al., 2019, p.20). A qualitative strategy will be followed, with the search of observed phenomena and the establishment of cause-effect relations.

3. LITERATURE REVIEW

3.1 INTRODUCTION

A gap was identified, and it was that no tool was broadly disseminated, known, available and commonly perceived by organizations in the IT sector of business that helped those responsible people with the decision to choose an IT project to invest in their hands. With the purpose to fill the gap, a literature review serves as foundation to the design of this tool. The reviewing of the literature starts with the aim of an in-depth reviewing of the three main pillars (fig.3), that will serve as a base to build the desired IT project selection decision-making model.

First regarding IT Projects: Its characteristics, the intangibles recognition and appreciation. Secondly to enter the IT project Portfolio discussion. This discussion is also sustained in the gains obtained in the previous IT projects analysis. Third, a tour for some decision-making models "on the market." Understand the underlying idea that stands in their decision-making process. Hence, this chapter will bring the necessary theoretical knowledge to dare in the new decision-making model quest, depicted in chapter four.

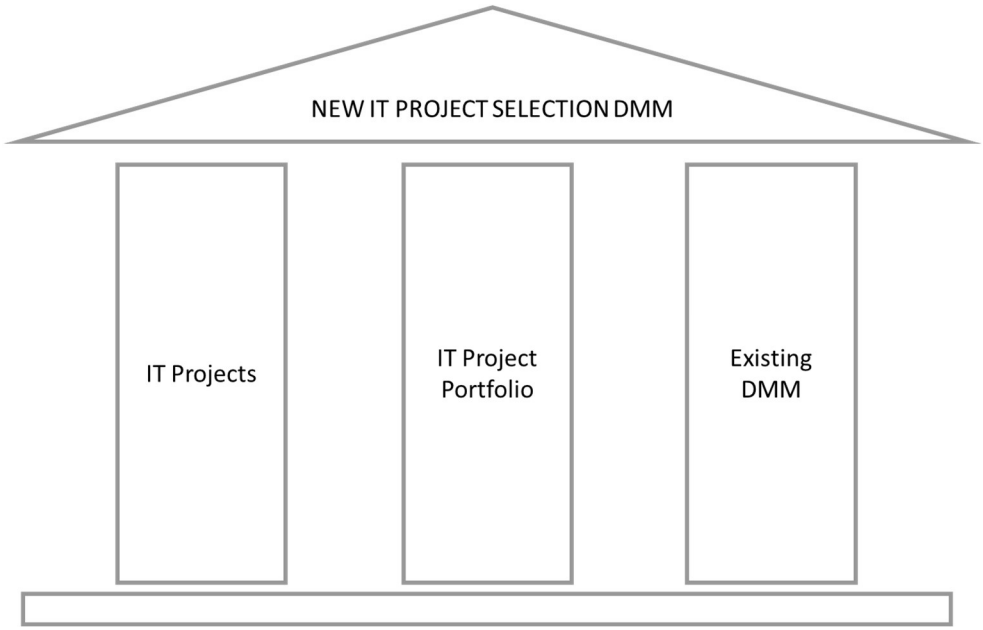

Figure 3 - Three pillars of the literature review

3.2 IT PROJECTS

As stated in the Project Management Book of Knowledge, PMBOK (2017, p.4), a project is "a temporary endeavour undertaken to create a unique product, service or result". So, IT projects are projects that involve primary the conception, development, or acquisition of a physical or logical IT solution destinated to overcome an identified IT need.

Basically, IT projects can be separated in two major categories: Those that are built in-house by software companies, with a dedicated software developing team, normally as part of the IT department. The fact itself that inner human resources are allocated to the coding of a software, or to build a physical product as a service revest itself in a project. On other hand, IT or non-IT companies do acquire finalized products, customizable or not to its specific businesses processes, with its implementation to be considered as well an IT project. This separation is aligned with the difference between an IT software company or just an IT company. The first one is responsible to the creation and maintenance of software and the second with the insurance of systems, software, and devices symbiosis (compliance).

In an increasing technological world that lives an irreversible IT trend, with a countless number of organizations 100% online, bigger investments in cybersecurity, artificial intelligence, 5G, among others, IT projects are crucial for organizations competitive survival towards its digital transformation and therefore their competitiveness.

So, IT is commonly one of the most important business values for any given company. To take the endeavour of getting the company in the edge of its business, IT sustained, an evaluation is to be made. This evaluation translates in measuring the as-is actual state and defining a plan to the out-to-be state. Sometimes, this out-to-be state requires IT investment.

3.2.1 Evaluate Strategic IT Needs

In figure 4., we can see depicted the evaluation flow to the identification of an IT solution need. As we will see further ahead, all endeavours should be emanated by a strategic point of view. This means that it must be aligned with the highest company decision level. The goal is to maintain and desirably elevate the company competitiveness, so any investment should produce valour in contribution to the vision and the mission that the strategic level as defined. Before any investment decision, the first step is to measure what we have. To measure it, a road is to be followed starting with an assessment of the company's business value. To do that benefit and cost should be compared. The business value determines the level of investment need to leverage the company competitiveness. If a high business value is obtained that translates that or the company has no rivals (it happens so in case of a disruptive business, that the company owns or manage like no other in the market) and therefore the need of IT

investment is due for expansion reasons, or it is a highly competitive company, that despite its markets opponents has a profitable market share. In other hand, a low business value means that the business needs a leverage (do note that can not necessarily be an IT boost, but as we are focused on IT projects, I assume that other factors were accessed), it needs an investment.

Measure the business performance means to access the internal engineering processes, for instance at the financial, development, innovation, and customer perspectives, among others. With pre-established indicators that state good, average, or deficient performance, valuable insights can be read to ease IT projects future investments needs, and in what areas of the business these new IT solutions should focus on.

The end of the road is reached with a justification of an IT investment, specified with the conclusions obtained in the previous steps. This specification book should than be presented to the responsible(s) for the company IT governance, that will include it in the company IT projects investment portfolio.

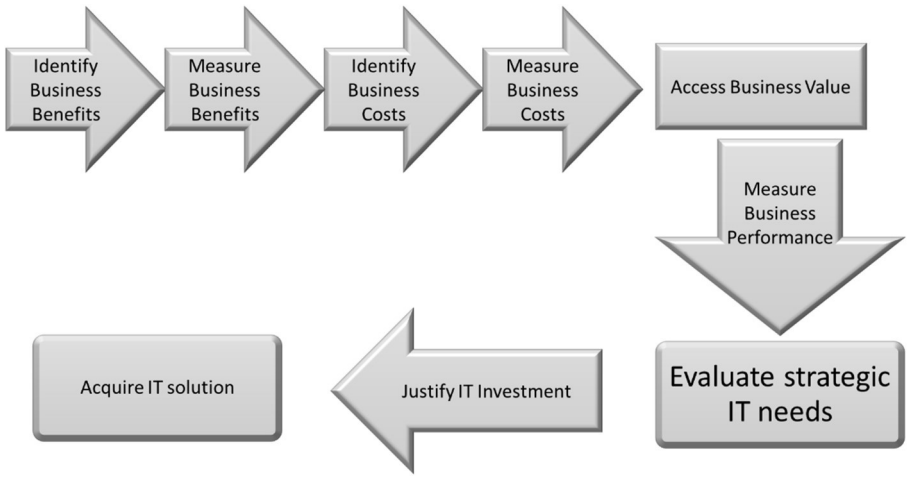

Figure 4 – Strategic IT need evaluation

3.2.2 IT Project Management: strategic alignment

Every major IT project should strategically align so it becomes important to define “strategic alignment” in IT. First the organizational risk. According with Cameron (2011, p.6) “This refers to how well the stakeholders embrace some new IT solution to a business problem”. So, the “team” should be on board. In companies the strategic alignment ensures that the IT services matrix is aligned with the processes and the objectives of the business. When we narrow it to IT projects it means that the end, goal, and

final product of the project should be evaluated, decided, and ensured with the commitment of the senior management of the company, so that the outcome of the project contributes to the business and creates value.

(Luftman, 2015) emphasises that this alignment addresses both how IT is aligned with the business and vice-versa, creating value by ensuring that organizations can create value out of their IT assets. At the first level of decision and evaluation of an IT project to invest in, the strategic alignment is the crucial factor to identify. It is or it is not aligned, and if not, it is a no-go condition. This will be of course embedded in the decision-making model of the study. If a project doesn´t gather the senior and strategic board approval, within the company vision and mission, and if it is not foreseen to add value to this vision and mission, then it is pointless.

Luftman also relates the strategic alignment maturity of the companies with some productivity indicators suggesting that high alignment maturity levels are linked with better company performance. Projects must walk alongside the organization values, a clearly defined vision, a clearly defined mission (Davis, 2013). They must contribute to the firm's incomes, effectively using its resources and leverage the company for the future.

3.2.3 Tangibles and intangibles assets

According with the Brand Finance Institute (2021, p.45), “In 1996, $131 billions of intangible asset value was recognized on balance sheets worldwide. Today, this figure stands at $15.4 trillion.”
This statement translates the increasing importance and recognition of intangible assets in organizations. This study, from September 2021, was made by Brand Finance, the world's leading brand valuation consultancy company. Two notes from this study: first is that the growth of the value of intangible assets increased 1000% in the last 25 years; the second is the ranking of the most valuable intangibles companies: 8 out of 10 of the topmost valuable intangibles companies are from the IT sector. The first two are Microsoft, with a value of 1,904 billion USD, relegating Apple to second this year with 1,871 billion USD.

What are intangible assets? Several authors (Hubbard, 2008), (Cohen, 2013), (Fuad & Gomes,2017) define intangibles as all assets that cannot be physically touched and therefore the difficulty of measure intangibles and quantify the value to the company.. Intangible assets are blends or combinations of procedures, practices, relationships, and culture (Moberly, 2014) that creates efficiency, enhance relations, and provide advantages.

The first way to a company to identify the presence of intangibles is to look at its tangible value (assets, business revenues, capital invested, etc) and then compare this number with the company market value.

Usually, a lot more. Why? Why will a buyer have to pay more that the assets and the economic business incomes that a company worth? This fact so exposed in M&A businesses translates the notion of Goodwill. Goodwill is the justified paid price, but for unknown reasons. The investor knows its importance despite its difficulty to quantify.

Accordingly with Wojciechowska (2016, p.38), a competitive advantage may concern good products and the ability to serve them faster or it may derive from skills that the company must better serve its clients. Sometimes you cannot quantify these skills, they are intangibles.

Lowering the scale, it is time to identify these intangibles within organizations and within IT projects. This identification will be crucial in the IT projects appreciation and in their own dispute in the portfolio context that will be addressed later in the study. We have already seen the growing importance of the intangible's identification, appreciation, and accounting in the modern enterprise businesses world. When an IT project is on the horizon, to look at these characteristics can translate a more accurate evaluation of the project, of its benefits, as important insights to compare a concurrent project to invest. IT related intangibles can be separated in several categories, and the importance of each is to be assessed by the company, so that the proper importance is assigned to the asset. Depicted in the table 1, we can see some examples of intangible assets:

Table 1 - Intangible Assets examples

Intangibles examples					
Marketing	**Contract-based**	**Customer related**	**Technology**	**HR related**	**Business Processes**
Trademarks	Customer lists	Licensing agreements	Patented technology	Work satisfaction	Knowledge
Newspaper mastheads	Order backlog	Service contracts	Computer software	Organizational commitment	Processes
Internet domain names	Customer relationship	Lease agreements	Trade secrets (such as secret	Teamwork	Organizational infrastructure

Noncompetition agreements Public relations Image Brand equity Goodwill	Suppliers Relationship	Franchise agreements Broadcast rights Employment contracts Use rights (such as water or drilling rights) Client satisfaction	formulas and recipes) Programming Code Intellectual Property Copyrights R&D	Employee satisfaction Human capital Stress reduction Academic education	

So, the new decision-making model will encompass a look at the IT candidate projects and their attached intangible assets. Will the new IT project impact a change in the organization business processes? Will it be required in the future to produce the same with less work? Or even produce more with less or the same work? Will it benefit HR daily quality work? Save time? Will it engage HR? Engage new clients? New stakeholders? Does it stand for a new disruptive product? Or a new disruptive way to do things? How can an organization equate future IT projects without a close look at intangibles? Kaplan's Framework (fig.5) depicts in a straightforward way how intangibles can be transformed into tangible profits

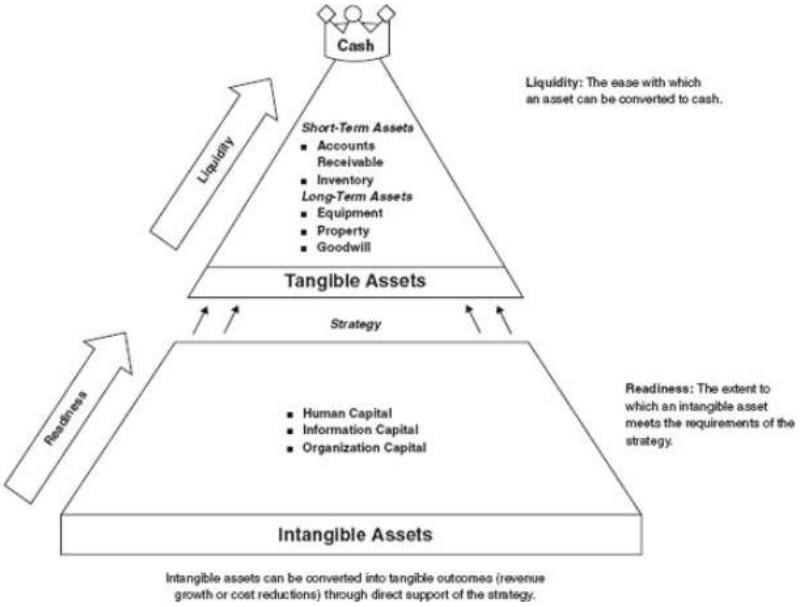

Figure 5 - Framework for Measuring Intangible assets.

Source: (S.Kaplan & Norton, 2004)

Strategic aligned intangibles (high readiness) do become tangibly accounted by internal processes increasing profits.

3.3 IT PROJECT PORTFOLIO

Simple: The concept of a portfolio, with several pages inside, from different proveniences, but all related to the portfolio subject. All gathered and able to be compared. The primary essence of PPM is not to do a specific project in the wright way, but to choose the wright project. In this sense, PPM is quite different than project management, though of course they are much related.

So, as seen in previous chapters, a path is followed that will end with a decision-making model. The business objectives and requirements were identified a led to a need analysis. Now we have IT projects in a portfolio that can or cannot fulfill the needs. A decision model will be applied to projects within the portfolio. Obviously that an evaluation starts with a single project analysis, but it is the portfolio that will provide a comparative base to a pick. It is of the outmost importance that a Project Management Office or bureau is well established in the organization. The fact that a team of experts is dedicated to evaluating and assess the liability of future endeavors will for sure minimize project implementation failure. The fact that every project that sees the daylight has been previously well studied, risks assessed by a team, eases the decision board to commit itself to the project, and is responsible for the project portfolio maintenance. Usually, it should be under a high hierarchical position collaborator, such as a vice-president of operations or a coo (chief operations officer), that must keep the portfolio vitality: the

continuous portfolio *feeding* with new projects and keeping the status of the projects that already are in the portfolio as viable. Not only to consistently search for ways to thrive business with projects, but to assure that the available ones are still updated and ready to be chosen to invest.

Figure 6 depicts what I consider the *portfolio management pentagon*, as a cycle that must be permanently filled. It starts with the project selection. Its maintenance checking the actual state of a given project in the portfolio, assuring it is ready, actual, and updated to be chosen. Next the execution: to select the project ensuring its alignment with the organization stands. Next is the analysis. To check that the projects course is on the right path. Normally there is a direct liaison to the project management office and imbed lessons and feedback in the portfolio management. This can for example provide valuable insights from other projects in the portfolio do be excluded or highlighted. At this stage analytical tools such as dedicated portfolio software can be used. Finally, it is made the portfolio cycle evaluation, new project prioritization a new project selection.

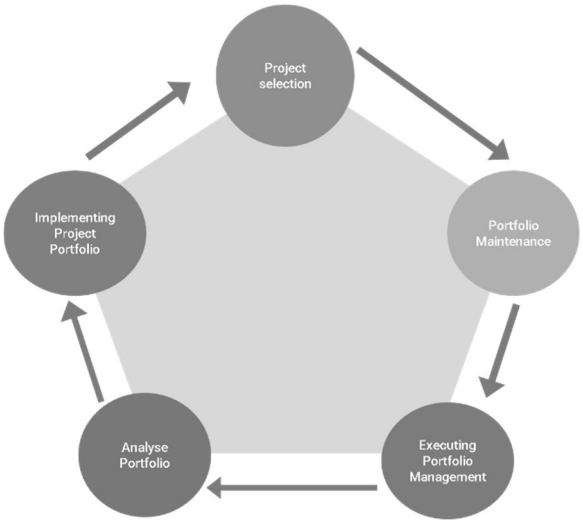

Figure 6 - The Portfolio Management Pentagon

Levine stated five simple and practical characteristics of what portfolio management is about (Levine, 2005, p.239):

1. Defining goals and objectives—clearly articulate what the portfolio is expected to achieve.
2. Understanding, accepting, and making trade-offs—determine how much to invest in one thing as opposed to something else.

3. Identifying, eliminating, minimizing, and diversifying risk—select a mix of investments that will avoid undue risk, will not exceed acceptable risk tolerance levels, and will spread risks across projects and initiatives to minimize adverse impacts.

4. Monitoring portfolio performance—understand the progress that the portfolio is making toward the achievement of the goals and objectives.

5. Achieving a desired objective—have the confidence that the desired outcome will be achieved given the aggregate of investments that are made.

3.4 DECISION MAKING MODELS

As seen in the previous subchapter, the portfolio management cycle, depicted on the pentagon of fig.6, starts with the project selection. To ease this project selection process, several authors have published different approaches, with scoring methods applied to the selection criteria, building models that help in the decision-making process.

The Multi Criteria Decision Making (MCDM) is characterized with the construction of a decision matrix, with criteria posted by the decision maker and alternatives to the chosen criteria. There are several types of MCDM available, some more appropriate to a specific sector of business than others. Health and pharmaceuticals, financial, management, are example of areas that strongly apply MCDM to decide in a more sustained, more balanced, insured and in a more rapid way. As methods examples, I can cite Complex Proportional Assessment (COPRAS), Elimination and Choice Expressing the Reality (ELECTRE), the compromise ranking method VIKOR, Promethee*, Tomada de Decisão Interativa Multicriterio* (Portuguese acronym for Interactive Multi-Criteria Decision Making) TODIM, Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Analytic Hierarchy Process (AHP), among others. We will have a look at the TOPSIS and the AHP method to a better understanding of MCDM.

3.4.1 Models approaches examples

3.4.1.1 TOPSIS

Topsis (Ching-Lai Hwang, 1981) has is named derived for its English denomination, that is *Technique for order preference by similarity to ideal solution*, and it is based in rankings. This method emphasizes that a determined alternative is desirably placed in a shorter distance regarding an ideal alternative (best solution) and the greatest distance from an anti-ideal alternative, that represents the worse scenario. The ideal alternative (not necessarily observed) is determined from the best values from the group of alternatives. In the same way, the anti-ideal alternative is determined from the worst values of the group of alternatives.

In table 2., is an example for better understanding:

Table 2 - Criteria and Alternatives TOPSIS table

	Criteria 1 Max	**Criteria 2 Min**	**Criteria 3 Max**
Alternative A	2	4	6
Alternative B	1	**1**	2
Alternative C	**3**	5	**7**
IDEAL	3	1	7
ANTI-IDEAL	1	5	2

source: (Ching-Lai Hwang, 1981)

Starting with a given multicriteria problem, a table with three criteria and three alternatives. The first and the third criteria represent something desirable, therefore maximized. The second criteria represent something undesirable, so minimized. So, the ideal alternative is the one that maximizes the desirable criteria and minimizes the undesirable one. So, in bold we can see the selection of the desirable alternatives following both criteria. As the TOPSIS model principle says, the objective is the maximum approach to the ideal alternative and the maximum distancing front the anti-ideal alternative.

This is briefly how the TOPSIS model starts. Following in figure 7. is a way to see the distance between the ideal and anti-ideal. The C axels represent a 2 criteria problem, and the letters are the 5 alternatives. To build the ideal alternative, we should select the max value from the 5 alternatives in each criterion. In this case, the maximum value for criteria 1 is the alternative E. To the criteria 2, the alternative A. The

junction of these two points is the ideal alternative. To determine de anti-ideal alternative, we should select the minimum value within the 5 alternatives for each criterion. In the example, the min. value for criteria 1 is the alternative A. For the criteria 2, the alternative E. this way we have the anti-ideal alternative.

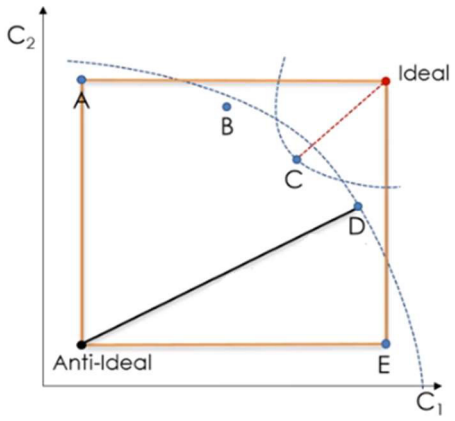

Figure 7 – Illustration Euclidean distance
source: (Yilmaz & Harmancioglu, 2010)

Now, to establish which the closest alternative to the ideal one is, we draw semi-circles, with center in the ideal alternative. As we can see the closest alternative to the ideal is C.

The line segment that joins the C alternative with the ideal one is a Euclidean distance. In the same way, we draw semi-circles with center in the anti-ideal alternative to find the most distant alternative from it, as depicted is the alternative D. Curiously we can see that not always the closest alternative to the ideal one is the most distant from the anti-ideal one. This way is found the best alternative with a ratio that encompasses both distances.

To find the Euclidean distance, the following mathematical formula is applied:

$$d_i^+ = \sqrt{\sum_{J=1}^{n} \left(d_{ij}^+\right)^2}$$

for the ideal alternative and

$$d_i^- = \sqrt{\sum_{J=1}^{n} \left(d_{ij}^-\right)^2}$$

for the anti-ideal alternative. So, the following TOPSIS steps are:

1. Define the decision matrix (criteria and their weight, alternatives, and their attribute value).
2. Normalization of the matrix.
3. Build the decision matrix (including each value with the criteria weighting).
4. Determine the ideal and the anti-ideal alternatives.
5. Distance measure calculation (determine each alternative distance to the ideal and anti-ideal solution).
6. Calculation of the relative proximity to the ideal alternative. $(\overline{RSi})ratio\ calculation.$

Let us do an example (table 3), for better understating. Imagine that we are rating suppliers of a given product:

Table 3 - First decision Matrix

	Cost (Co) min	Quantity (Ca) min	Durability (DU) max
Supplier 1	185	6,5	12.850
Supplier 2	290	7,5	13.695
Supplier 3	310	7,6	12.870
Supplier 4	245	6,5	11.385
Supplier 5	325	7,55	11.235
Supplier 6	235	6,85	12.525
Weight Criteria	0,30	0,40	0,30

source: (Ching-Lai Hwang, 1981)

Less value to cost, so minimum criteria. Less resources to quantity, minimum criteria. Maximum durability. Next weight the criteria (with SUM=1). The values to fill the rest of the matrix were randomly chosen. Here we have concluded step 1.

Step 2 is about normalization. This step is important given the different matrix fields reality. To obtain a normalized TOPSIS matrix, we should do the following operation

$$V_j^i = \frac{r_{ij}}{\sqrt{\sum_{i=1}^{m}(r_{ij})^2}}$$

Starting with the vector norm

$$\sqrt{\sum_{i=1}^{m}(r_{ij})^2}$$

Table 4 - Topsis Table vector norm calculation results

Vector Norm	**659,77**	**17,39**	**30.537,49**

(Ching-Lai Hwang, 1981)

As example, the value 659,77 is obtained from the following calculation:

$$\sqrt{185^2 + 290^2 + 310^2 + 245^2 + 325^2 + 235^2}$$

Applying the weight criteria (table 5):

Table 5 - Normalized Topsis Matrix

	Cost (Co) min	Quantity (Ca) min	Durability (DU) max
Supplier 1	0,0841*	0,1495	0,1262
Supplier 2	0,1319	0,1725	0,1345
Supplier 3	0,1410	0,1748	0,1264
Supplier 4	0,1114	0,1495	0,1118
Supplier 5	0,1478	0,1737	0,1104
Supplier 6	0,1069	0,1576	0,1236

source: (Ching-Lai Hwang, 1981)

*0.0841=0,2804 x 0,30

Distance measures. Applying the following mathematical formulas, we can calculate the distance to the ideal and anti-ideal alternative.

Table 6 - Alternative distance TOPSIS table

	Cost (Co) min	Quantity (Ca) min	Durability (DU) max	Distance to ideal alternative $d_j^+ = \left[\sum_{i=1}^{n}(v_{ij} - v_j^+)^2\right]^{\frac{1}{2}}$	Distance to anti − ideal alternative $d_j^- = \left[\sum_{i=1}^{n}(v_{ij} - v_j^-)^2\right]^{\frac{1}{2}}$
Supplier 1	0,0841*	0,1495	0,1262	0,008301	0.070315
Supplier 2	0,1319	0,1725	0,1345	0,052995	0,029028
Supplier 3	0,1410	0, 1748	0,1264	0,062740	0,0174509
Supplier 4	0,1114	0,1495	0,1118	0,035487	0,044334
Supplier 5	0,1478	0,1737	0,1104	0,072247	0,001150
Supplier 6	0,1069	0,1576	0,1236	0,026469	0,046348
Ideal Alternative	0,0841	0,1495	0,1345	$\sqrt{(0{,}0841-0{,}0841)^2+(0{,}1495-0{,}1495)^2+(0{,}1345-0{,}1262)^2}$	
Anti-ideal alternative	0,1478	0,1748	0,1104	$\sqrt{(0{,}1478-0{,}0841)^2+(0{,}1748-0{,}1495)^2+(0{,}1262-0{,}1104)^2}$	

Source: (Ching-Lai Hwang, 1981)

The next step is to calculate the relative proximity of one alternative to the ideal alternative (step 6). We use the following equation:

$$\overline{RSi} = \frac{\bar{d}_i^-}{\bar{d}_i^- + \bar{d}_i^-}$$

Table 7 - Relative proximity TOPSIS table

	Distance to ideal alternative $d_j^+ = \left[\sum_{i=1}^{n}(v_{ij} - v_j^+)^2\right]^{\frac{1}{2}}$	**Distance to anti − ideal alternative** $d_j^- = \left[\sum_{i=1}^{n}(v_{ij} - v_j^-)^2\right]^{\frac{1}{2}}$	$\overline{RSi} = \frac{\overline{d_i^-}}{\overline{d_i^-} + \overline{d_i^-}}$
Supplier 1	0,008301	0.070315	0,89440807
Supplier 2	0,052995	0,029028	0,35389727
Supplier 3	0,062740	0,0174509	0,21761056
Supplier 4	0,035487	0,044334	0,55542180
Supplier 5	0,072247	0,001150	0,01566870
Supplier 6	0,026469	0,046348	0,63650296

$$\frac{0{,}070315}{0{,}008301 + 0{,}070315}$$

$$\frac{0{,}001150}{0072247 + 0{,}001150}$$

source: (Ching-Lai Hwang, 1981)

Now we can establish a rank table:

Table 8 - Suppliers Rank

1	**Supplier 1**	**0,89440807**
2	Supplier 6	0,63650296
3	Supplier 4	0,55542180
4	Supplier 2	0,35389727
5	Supplier 3	0,21761056
6	Supplier 5	0,01566870

source: (Ching-Lai Hwang, 1981)

see that the ideal alternative is supplier 1 and the anti-ideal alternative is supplier 5.

3.4.1.2 AHP

The analytic or analytical hierarchy process (AHP) is a structured way for organizing and analyzing complex decisions. Original developed by Saaty (Saaty, 1980), it is one of the broadest used MCDM in the world. AHP does an excellent job treating qualitative data and its consistency verification is regarded as one of its most significant advantages.

The three bases of AHP are hierarchy construction, priority analysis, and consistency verification. To do so, a six steps process, as we did with TOPSIS, are to be followed (Mu & Pereyra-Rojas, 2018, p.14):

1. Develop a model for the decision: Break down the decision into a hierarchy of goals, criteria, and alternatives.

2. Derive priorities (weights) for the criteria: The importance of criteria is compared pairwise with respect to the desired goal to derive their weights. We then check the consistency of judgments; that is, a review of the judgments is done to ensure a reasonable level of consistency in terms of proportionality and transitivity.

3. Derive local priorities (preferences) for the alternatives: Derive priorities or the alternatives with respect to each criterion separately (following a similar process as in the previous step, i.e., compare the alternatives pairwise with respect to each criterion). Check and adjust the consistency as required.

4. Derive overall priorities (model synthesis): All alternative priorities obtained are combined as a weighted sum to consider the weight of each criterion — to establish the overall priorities of the alternatives. The alternative with the highest overall priority constitutes the best choice.

5. Perform sensitivity analysis: A study of how changes in the weights of the criteria could affect the result is done to understand the rationale behind the obtained results.

6. Making a final decision: Based on the synthesis results and sensitivity analysis, a decision can be made.

Let's start developing an example for an easy understanding. The objective is to find the better alternative within the available ones…with criteria. If we want to select a beverage, what criteria should be considered? Temperature, sweetness, alcohol level, and so on. The alternatives are the beverages. This is clearly the goal when applying a MCDM model to a project portfolio. Finally, a better IT Project to invest in should be obtained.

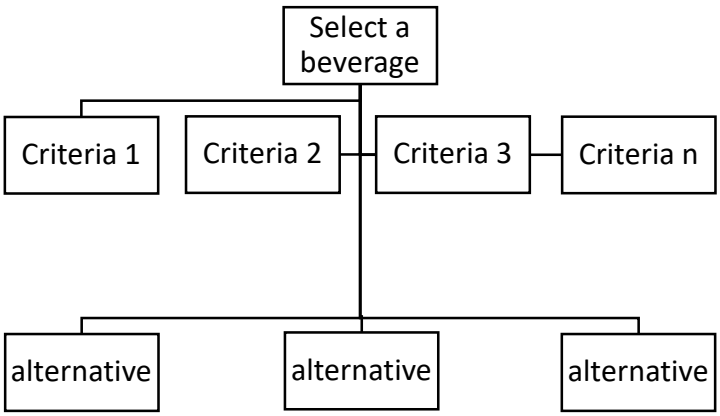

Figure 8 - AHP Best Alternative Process

In figure 8 above we can see that in AHP each alternative is subject to a set of criteria. This means for each decision taken, this decision encompasses the criteria evaluation. When a full matrix is established, with columns criteria and alternative rows, well defined, we are set to go to step 2.

In this step we must establish the criteria's importance. Obviously, different criteria have different importance. For example, can Cost overcome quality? Supplier delivery speed? If an IT project is fully aligned with the company mission or does it contribute only in a short way to it?

How do we state this importance? By comparing all the criteria known for the project alternatives. The comparison and weighting tool are based in Saaty's pairwise comparison scale:

Table 9 - Saaty´s pairwise comparison scale

Verbal judgment	Numeric value
Extremely important	9
	8
Very strongly more important	7
	6
Strongly more important	5
	4
Moderately more important	3
	2
Equally important	1

source: (Saaty's 1981)

The intermediate values 2, 4, 6, and 8 are used to address situations of uncertainty.

In the table 10, here is how the weighting is made: Starting with the criteria 1, following the row, the decision-maker establishes that the criteria 1 is 5 times "strongly more important" that the criteria 2 (do not forget to classify within the table 8 ranks. So, in red we can see that the number 5. In the opposite sense, in purple we see the number 1/5 that means if the criteria 1 is 5 times more important or "strongly more important" than the criteria 2 then the criteria 2 is less important 5 times, therefore 1/5 is the number to fill.

Table 10 - AHP Criteria weighting

	Criteria 1	**Criteria 2**	**Criteria 3**	**Criteria n**
Criteria 1	1	5	1/3	4
Criteria 2	1/5	1	1/9	1/2
Criteria 3	3	9	1	5
Criteria n	1/4	2	1/5	1

source: (Saaty's 1981)

The number of comparisons is always the rank number of the matrix multiplied by the rank -1, divided by 2, in this case the rank is 4, so we will have 4*3=12, 12/2= 6 comparisons.

Next, we sum up the criteria weights (table 11.)

Table 11 - Criteria Sum – normalization step1 table

$\sum r_i$	**4,45**	**17**	**1,64**	**10,50**

The next step is to proceed to the normalization of the matrix. Here we divide each criteria weight with the sum of the weight that belongs to it.

The formula $V_i = \frac{r_i}{\sum r_i}$ is used to normalize the matrix, as depicted in table 12.

Here is the normalized table. As you can see, the sum as to be equal to 1.

Table 12- Criteria Sum - normalization step 2 table
source: (Saaty's 1981)

	Criteria 1	Criteria 2	Criteria 3	Criteria n
Criteria 1	0,2247	0,2941	0,2027	0,3810
Criteria 2	0,0449	0,0588	0,0676	0,0476
Criteria 3	0,6742	0,5294	0,6081	0,4762
Criteria n	0,0562	0,1176	0,1216	0,0952
$\sum r_i$	1,0000	1,0000	1,0000	1,0000

source: (Saaty's 1981)

In the same way, we can calculate the priority vector the contribution of each criterion. It is calculated by the formula $R_j = \frac{v_j}{\sum v_j}$

Table 13 - Priority vector

	Criteria 1	Criteria 2	Criteria 3	Criteria n	Priority Vector
Criteria 1	0,2247	0,2941	0,2027	0,3810	0,2756
Criteria 2	0,0449	0,0588	0,0676	0,0476	0,0547
Criteria 3	0,6742	0,5294	0,6081	0,4762	0,5720
Criteria n	0,0562	0,1176	0,1216	0,0952	0,0977

source: (Saaty's 1981)

Criteria 3 is the criteria that as a bigger contribution to the objective. The column is to sum 1, so we can say that the criteria 3 as a contribution or a weight of 57%.

For instance, if the criteria 3 was the alcohol level of the beverage we could state that this had a 57% impact on my choice. But are these values consistent? AHP does have a way to analyze the consistency

of the values obtained, and if they need correction or deep analysis. To obtain the consistency we start from the initial criteria comparison matrix, and we multiply it with the priority vector. So:

Table 14 - AHP Consistency - first step

	Criteria 1	Criteria 2	Criteria 3	Criteria n	Priority Vector	λw
Criteria 1	1	5	1/3	4	0,2756	1,1306
Criteria 2	1/5	1	1/9	1/2	0,0547	0,2222
Criteria 3	3	9	1	5	0,5720	2,3796
Criteria n	1/4	2	1/5	1	0,0977	0,3904

source: (Saaty's 1981)

To value of λw for criteria 1 is obtained by doing the following math:

(1*0,2756) + (5*0,0547) +(1/3*0,5720) + (4*0,977).

To this new table (λw), we sum the priority vector table sum:

Table 15 - AHP Consistency table - Step 2

Priority Vector	λw	λj
0,2756	1,1306	4,102201
0,0547	0,2222	4,062624
0,5720	2,3796	4,16014
0,0977	0,3904	3,995906

source: (Saaty's 1981)

We sum the λ_j values and divide by the number of rows (4).

(4,10+4,06+4,16+3,99)/4.

The result is 4,0801. This value is the n_{max}. And it will be used to calculate the consistency index.

IC = Consistency Index

$$IC=\frac{n_{max-n}}{n-1} = \frac{4.081-4}{4-1} = \frac{0,081}{3} = 0,0207$$

Having the IC, we need to calculate the RI (random index) $\frac{0,9(n-2)}{n}$= 0,45

Last, we calculate the CR (consistency reason) = $\frac{IC}{RI} = \frac{0,0207}{0,45}$ =0,046

A consistency ratio (CR) of 0.10 or less is acceptable to continue the AHP analysis. So, 0,046 < 0,10 the work so far is consistent.

But what is still missing is the ranking of the alternatives based on the criteria impact. Here is an example of a simple comparison matrix that establishes the criteria weighting (Financial, Speed (delivery) and Costs – F, S, C) to the paper suppliers of a school (PERCO(P), RIZA(R), ESUB(E)):

Table 16 - AHP Comparison Matrix

	F	S	C
F	1	1/2	1
S	2	1	4
C	1	1/4	1

source: (Saaty's 1981)

At this point the interpretation of the matrix of table 14 is easy, filled with the Saaty scale (table 7). Tables 15, 16 and 17 show the comparison of the suppliers from the financial, speed and costs point of view:

Table 17 - Comparison of suppliers from the financial view

	P	R	E
P	1	1/3	4
R	3	1	5
E	1/4	1/5	1

source: (Saaty's 1981)

Table 18 - Comparison of suppliers from the speed view

	P	R	E
P	1	2	1/3
R	1/2	1	1/2
E	2	2	1

source: (Saaty's 1981)

Table 19 - Comparison of suppliers from the cost view

	P	R	E
P	1	2	1/3
R	1/2	1	1/2
E	2	2	1

source: (Saaty's 1981)

In table 17., we can see that PERCO is 4 times better than ESUB from the financial point of view, that means for example that the payment schedule or plan is more adequate to the company if PERCO is the chosen supplier. The same goes for the cost matrix.

In figure 9, is depicted the decision tree where we can see that for each criterion there are 3 available alternatives. Note that the criteria have already their weights (calculated as we did in the previous exercise).

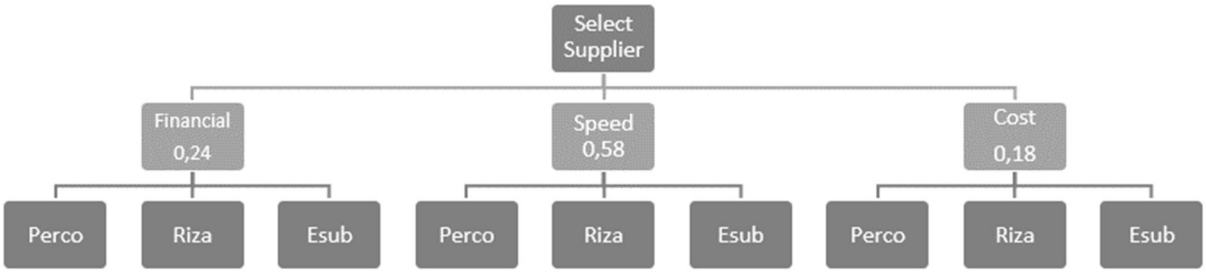

Figure 9 - Decision Tree

So now we need to know that with the given criteria weight how the different alternatives stand. How PERCO is classified in financial terms or how ESUB is speed wise for example. It is achieved through the normalization of the different matrix (see steps made between table 10 to 12). So here are the results:

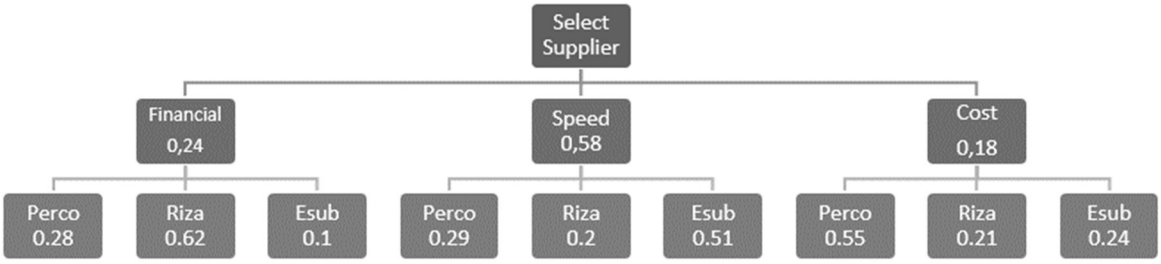

Figure 10 - Decision Tree with Criteria and alternatives weighting

The final evaluation is to select the supplier. To know the supplier's final grade, we must sum the different alternative classifications multiplied for the criteria,

PERCO: (0.24 *0.28) + (0.58*0.29) + (0.18*0.55) = 0.3344

RIZA: (0.24*0.62) + (0.58*0.2) + (0.18*0.21) = 0.3026

ESUB: (0.24*0.1) + (0.58*0.51) + (0.18*0.24) = 0.363

ESUB is the supplier with the highest rank with 36,3%. This data should after being analyzed regarding its consistency as we did in the previous exercise/example.

3.4.2 Discussion

In this chapter an approach to MCDM methods was made. Of the several available MCDMs, two were more in detail explained, but with a rational. The multi-criteria decision and consistency analysis of the methods. Their proven ability to be applied to project selection. The objective of the thesis is to develop an MCDM applied to the IT project selection in the portfolio context. AHP methodology allows this data crossing to find which alternatives are better based on pre-determined criteria. These criteria will be defined at distinct levels of the company, regarding the project weight and importance, always in the strategic perspective and alignment doctrine.

(Rai, 2004) stated "The AHP has proved a theoretically sound and market tested and accepted methodology. It is almost universal adoption as a new paradigm for decision-making coupled with its

ease of implementation and understanding constitute its success. More than that, it has proved to be a methodology capable of producing results that agree with perceptions and expectations."

It has several challenges: To encompass a multi-criteria decision process, the IT projects specifics, and the treatment of qualitative data as quantitative data. In the literature review readings, clearly the gap was found. First the little awareness regarding the intangible assets, resources, and incomes that an IT project evolves. Second, to build a model that can help choose an IT project to invest with its intangible's evaluation.

4. A DECISION-MAKING MODEL

The road to this chapter was traveled in previous chapters: From IT projects to Project Management to IT Project Portfolio. The importance of IT intangibles accounting nowadays and its hidden value. Now I am proposing a model that encompasses all these areas, rank them to find the most indicated solution based on structural vectors, such profitability, reward/risk balance and strategic alignment.
This labor should be conducted desirably by a project management office (PMO). Here Management, Project Management and Information Technologies melt themselves to provide knowledge to the model designing, decision and interpretation.

Where the model enters: In figure 11 it is depicted a sequence compiled in 7 phases that shows the Organization's road from need identification to satisfaction.

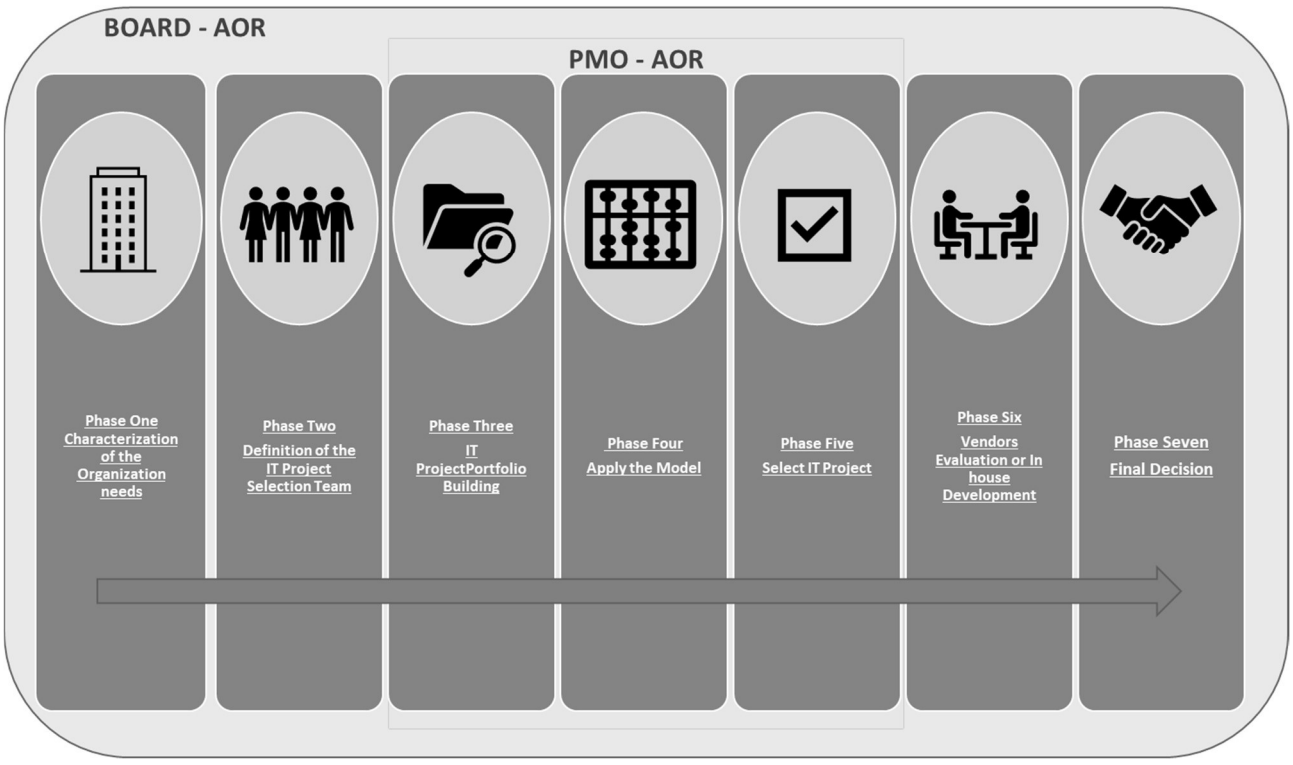

Figure 11 – Project Investment Decision Roadmap

4.1 PHASE ONE – CHARACTERIZATION OF THE ORGANIZATION NEEDS

This first phase is at the end under de exclusively Area of Responsibility (AOR) of the board. Though the feedback of a gap or an IT need (see fig.4) can be, and usually is, given by lower departments, the ultimate decision is from the Managing Board. This strategic level is responsible for outlining de vision and the mission of the company. A Need Analysis must be made: Strategic Objectives, Map de AS-IS

(current design) and the TO BE State (future one). Where it is and where is desired to be on a given timeline. To achieve this objective, resources are needed, tools are needed. The way to be clear across the Organization though its implementation and future success relies on it.

4.2 Phase Two – Definition of the IT Project Selection Team

The PPM should be endeavored by Project Management Professionals, simply because the IT Project selection is a Project itself. Facing a portfolio of IT projects to invest in, all the different areas of a project, its specifics, should be evaluated by SME's (Subject Matter Expert): IT, finance, HR, etc. These SME's will be the ones who will perform the 3rd phase steps. The portfolio management has itself to be managed as a project including but not limited to stakeholders, scope, time, cost, and risk management.

Following this thought, it should be identified and nominated by the Board/HR department the roles and the collaborators to build the Team, at least:

- The project portfolio manager.
- A sponsor from the board/senior manager to ensure strategic compliance as a natural stakeholder.
- Representatives from other stakeholders (Other Departments involved, engaged in the future IT solution, including IT professionals.
- If needed, an external SME as a consultant.

The size of the Project Selection Team varies normally in proportion to the size of the company itself and therefore its PMO. The PMO does PPM as the monitoring of ongoing projects, their eventual deviation from expected value and benefits. The bigger the portfolio or projects in execution, bigger the number of collaborators in the PMO.

4.3 Phase Three – IT Project Portfolio Building

In this phase, the first under the PMO responsibility, is where the PPM team is responsible to translate the identified organization needs and communicated by the Board to the PMO into projects. These projects will constitute a portfolio, all destined to fulfill these needs. It is an especially important phase because all the needs should be analyzed and documented, ready to be evaluated by de model that will assess its viability and standings regarding other projects in the portfolio. The management process should address the following (Levine, 2005):

- A ranking of value and benefits
- An appraisal of risk (in achieving these benefits)
- An inventory of resource availability and allocation
- An idea of an optimum or acceptable size of the project pipeline
- Development of tactical plans that would involve projects in support of the strategic plan
- Definitions of value and benefits as they apply to the tactical plans
- A long-range projection of resources strategies

The criteria applied to address these factors should be emanated from the strategic level, the board. Only this way is guaranteed that the portfolio is built aligned with the vision and the mission of the company.

At this point, the company should have a portfolio with several (two or more) IT projects. Projects are now evaluated *per se*. The next phase is where the PPM is about: a comparison of projects, confronting their pluses and cons, face resources availability and at the end, choose and propose to the board the project to invest. The 4th phase is where the decision-making process that will rank the projects is used, and the pipeline is filled by order.

4.4 Phase Four – Application of the model

4.4.1 Assumptions

Based on what was studied in the literature review and on a more effective approach to a more universal decision-making model there are a few assumptions to consider:

- IT organizations have varied sizes, different organizational structures, Information systems, Human Resources.
- Each organization has different IT needs.
- The number of variables can be added regarding the project components and their contribution to organizational objectives. The model is perfectly manageable to the inclusion of different variables, with proper weight analysis. For variables it is understand criteria, preferences, weights. All that can be included following a perception of its strategic importance.

- For illustrative purposes only a few criteria were considered. A company can value quality product more in contrast to production pace. The aim is to understand how it works, and less and simpler are the examples easier it is to demonstrate and acquire.

4.4.2 AHP Goal and Criteria

Apply the decision-making model starts with the establishment of the purpose, the goal. The goal here is to choose the best IT Project to invest from a portfolio of projects that compete among them to be selected. For a clear understanding, it is depicted in fig.12 as the basis of the decision model. Following the goal statement, the model should be filled with the criteria. It encompasses seven criterions that concur among themselves to provide a decision to achieve the goal. These criterions were chosen for academic and illustrative purposes (see assumptions).

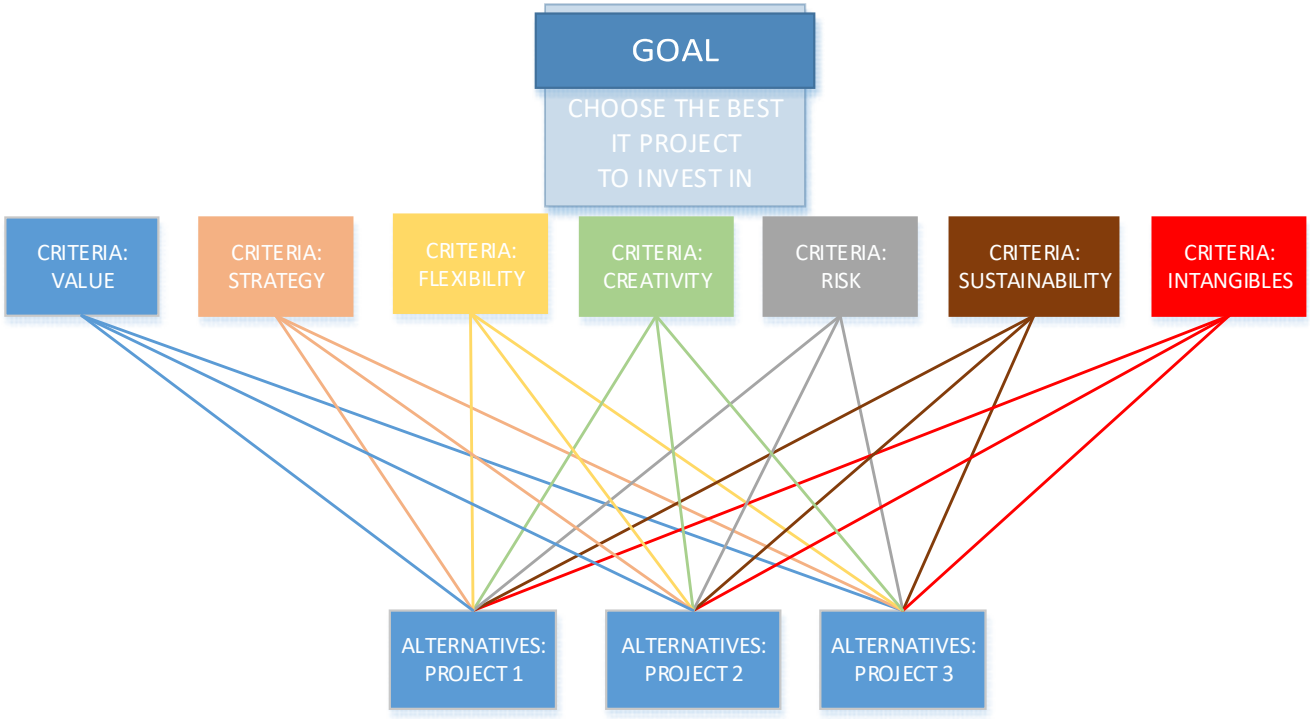

Figure 12 - Decision Model Goal, Criteria and Alternatives

Let us build our decision matrix. In the decision matrix will be stated the relationship between criterions, namely how a criterion stand in terms of importance to another by comparing all the criteria known for the project alternatives. Based in *Saaty´s pairwise comparison scale* (table 9), it is established the criterion importance comparison.

Table 20 - Decision-matrix - Criterion importance

	Value	Strategy	Flexibility	Creativity	Risk	Sustainability	Intangibles
Value	1	2	3	4	1	3	3
Strategy	½	1	2	2	1	3	2
Flexibility	⅓	½	1	1	1	½	½
Creativity	¼	½	1	1	⅓	2	½
Risk	1	1	1	3	1	2	2
Sustainability	⅓	⅓	2	½	½	1	1
Intangibles	⅓	½	2	2	½	1	1

In cell a3, we can see that value is considered 3 times more important than the flexibility criterion. In the opposite sense, in cell c1 we can see the flexibility has ⅓ of the value importance. The number of comparisons is always the rank number of the matrix multiplied by the rank-1, divided by 2, in this case the rank is 7, so we will have 7*6=42, 42/2= 21 comparisons.

Sum of the criteria weights:

Table 21 - Criteria sum - normalization step 1 table

$\sum r_i$	**3,75**	**5.833**	**12**	**13.5**	**5.33**	**12.5**	**10**

Normalize the matrix (V_i=$\frac{r_i}{\sum r_i}$) (table 22):

Table 22 - Normalized Table

	Value	Strategy	Flexibility	Creativity	Risk	Sustainability	Intangibles
Value	0.266	0,342859	0,25	0,296296	0,187617	0,24	0,3
Strategy	0,13333	0,171429	0,1667	0,148148	0,187611	0,24	0,2
Flexibility	0,0888	0,085714	0,0833	0,074074	0,187617	0,04	0,05
Creativity	0,06666	0,085714	0,0833	0,074074	0,062476	0,16	0,05
Risk	0,26666	0,171429	0,0833	0,222222	0,187617	0,16	0,2
Sustainability	0,0888	0,05708	0,166667	0,037037	0,09380	0,08	0,1
Intangibles	0,0888	0,085714	0,166667	0,148148	0,09380	0,08	0,1
$\sum r_i$	1	1	1	1	1	1	1

Priority Vector. The formula V_i= $\frac{r_i}{\sum r_i}$ is used to calculate it. From the data of the normalized matrix, we will get each criterion weight, followed by a consistency check.

Table 23 - Priority Vector

Priority Vector	
Value	27%
Strategy	17,9%
Flexibility	8,5%
Creativity	8,4%
Risk	18,5%
Sustainability	8,8%
Intangibles	10,9%

The consistency ratio is 0,049, so 4,9%. Less of 0,1 is considered consistent in AHP, so a good result.

Here is the criterion definition ordered by importance:

4.4.2.1 VALUE •

The first criterion is the perception of the value that a given IT project can bring in case of investment. Obviously, this definition will change before the company's focus, projects, and strategies. Value will be analysed from two perspectives: The strategic alignment and financial attractiveness. Depending on the company financial health, the financial part of the value criterion can have more weight. In a sustainable company, with consolidated operations and business results, the strategic alignment should be prioritized. The question is that a project strategically well aligned, with direct contribution to the business need and product should prevail over costs, obviously calculated ones. So, the inner-criterion distribution is always subjective and need to previous board/PMO office discussion.

4.4.2.1.1 Strategic Alignment

Strategic Alignment is measured to what degree is the project contributing to the company strategy. Schmidt (2021, p. 20) defines strategy as "…where you want to be in the future (Vision); how you plan to get there (Goals and Projects); and the stream of decisions you make along the way (Agile execution)". So…is the project contributing directly to the company mission? Does de project fulfil the board directives? For instance, acquiring a new software that predicts tides and ship drifts for a merchant navy directly impacts its operational labour and therefore its mission, with natural gains in its schedule management. Normally projects that have a more decisive importance in its contribution to the mission have more stakeholder's involvement. All IT projects must be aligned with the strategy. Selecting a software education and training program for two different areas (finance or CRM), one is always more important than the other regarding the company's strategy, so its alignment is more prevalent in one project.

4.2.2.1.2 Financial Attractiveness

There are a lot of different parameters to try to understand and forecast the financial competitiveness of a project. (Pinto, p. 115) states that "Financial models are all predicated on the time value of money principle. The time value of money suggests that money earned today is worth more than money we expect to earn in the future…We expect future money to be worth less for two reasons: (1) the impact of inflation, and (2) the inability to invest the money". There are several methods that a financial technician (preferably from the evaluation team) can use to this appraisal:

Net Present Value (NPV)

The NPV is usually used to help to assess how much an investment cash flow is worth. The mathematical representation is

$$NPV = \frac{Cash\ Flows}{(1-i)^t} - Initial\ Investment$$

where *i* stands for Required Rate of Return (return that the investor expects to receive) and t is time (period).

	Year 1	*Year 2*	**Year 3**	*Year 4*	*Total*
Benefits	$0	$850,000	**$3,500,000**	$7,400,000	
Operating costs	$610,000	$610,000	**$610,000**	$610,000	
Gross earnings	–$610,000	$240,000	**$2,890,000**	$6,790,000	
Investment costs	$1,200,000				
Taxes	–$291,200	–$19,200	**$828,800**	$2,076,800	
Cash flow	–$1,518,800	$259,200	**$2,061,200**	$4,713,200	
Discount rate @ 20%	1.2	1.44	**1.73**	2.07	
Present value	–$1,265,667	$180,000	**$1,191,445**	$2,276,908	$2,382,686

Figure 13 - Example of Present Value Calculations
source: (Levine, Harvey A., 2009)

Based in fig.13 example:

- Tax (32%) * $2,890,000= $924,800.
- Adjust for the year 3 tax benefit of depreciating your investment costs over four years: 32% × ($1,200,000 ÷ 4 years) = $96,000.
- Subtract the tax benefit from the taxes to get the total tax for year 3: $924,800 − $96,000 = $828,800.
- Apply the formula for the adjustment for risk and time (1 + r) t, where r is the annual discount rate and t is the time in years: (1 + .20)3 = 1.73.
- The cash flow from operations is divided by the adjustment to get the net present value of the cash flow for that year: $2,061,200/1.73 = $1,191,445.

- Doing this for each year in the project's life cycle provides the total net present value of the project's cash flows, or $2,382,686: −$1,265,667 + $180,000 + $1,191,445 + $2,276,908 = $2,382,686.

For instance, if the company add 25 million shares: 2,382,686/25,000,000 = 9cents per share. The project will upscale price by 9cents/share.

Internal Rate of Return (IRR)

The IRR is used to estimate the profitability of a potential investment. It is the annual return that makes NPV=0. Bonham (2005, p. 70), as the following definition. "The IRR is defined as the discount rate that evaluates the PV of the benefits (net cash flows) from a project with the PV of the total costs (net cash outflows). In a business case, obviously, the IRR is a projected value—it is the rate of return the project sponsor expects to get from the risky investment. The higher the perceived risk, the higher the expected IRR, in theory."

The formula is as follows:

$$0 = NPV = \sum_{t=1}^{T} \frac{Ct}{(1+IRR)^t} - C_0$$

Where:

$Ct = Net\ cash\ inflow\ during\ period\ t$

$C_0 = Total\ initial\ investment\ costs$

IRR= The internal Rate of Return

T= the number of time periods

Table 24 – Internal Rate of Return calculation

Period	Valor
1 (initial investment)	-125000€
2	30000€
3	40000€
4	50000€
5	50000€
6	60000€
IRR	**22%**

In this case, the IRR is 22%.

Total cost of Ownership (TCO)

The TCO can be used to analyze direct and indirect costs of specific technology implementations (Kenneth C. Laudon, 2020). In table 25 we can see some examples of cost components, per infrastructure component.

Table 25 - TCO Cost Components

1. INFRASTRUCTURE COMPONENT	2. COST COMPONENTS
3. Hardware acquisition	4. Purchase price of computer hardware equipment, including computers, terminals, storage, and printers
5. Software acquisition	6. Software acquisition Purchase or license of software for each user
7. Installation	8. Cost to install computers and software
9. Training	10. Training Cost to provide training for information systems specialists and end users
11. Support	12. Cost to provide ongoing technical support, helpdesks, and so forth
13. Maintenance	14. Cost to upgrade the hardware and software
15. Infrastructure	16. Cost to acquire, maintain, and support related infrastructure, such as networks and specialized equipment (including storage backup units)
17. Downtime	18. Downtime Cost of lost productivity if hardware or software failures cause the system to be unavailable for processing and user tasks
19. Space and energy	20. Real estate and utility costs for housing and providing power for the technology

Source: (Laudon & Laudon, 2019)

To all components Costs, it should be subtracted the estimated remaining value of the asset after a given operation period. An IT project should not be chosen based in its initial costs of deployment. We cannot forget that training, customization, and integration count.

Benefit-Cost Ratio (BCR)

The Benefit-Cost-Ratio is determined by dividing the proposed total cash benefit of a project by the proposed total cash cost. If BCR>1, the project is expected to deliver a positive NPV, so it is to be considered. It has as a limitation the fact that it reduces a project to a number when the success or failure of an investment is determined by so many factors.

Economic Value Added (EVA)

EVA is a measure of the company's financial performance based on residual wealth (deducing operation capital costs with taxes). "EVA is a year-by-year measure of how much economic profit the firm has created. On a per-share basis, EVA is also an estimate of how much the firm's stock price should have changed in a given year (assuming it was fairly valued at the beginning of the period)." (Weigand, 2014).

EVA= NOPAT – (Invested Capital * WACC)

Where:

NOPAT=Net operating profit after taxes.

Invested Capital= Debt + shareholder's equity + capital leases.

WACC= Weighted average cost of capital.

Return On Investment (ROI)

ROI is a metric to assess how well investment is performing. The formula is:

$$ROI = \left(\frac{Net\ Profit}{Investment}\right) * 100$$

A positive percentage will translate to a profit of the same percentage regarding the investment made. Note that achieving the investment value to apply in the formula isn´t always easy. The investment should encompass the TCO of the project.

Several other metrics can be used to assess the financial attractiveness of an IT project to invest. The metrics shown were a mere hypothesis from an academic point of view. The financial department or the PMO Office can, regarding each IT Project specifics, decide which metric should be the most accurate to return the intended information. The sum of return data of the strategic alignment and the financial attractiveness of the project compiled, will translate the weight of the value criterion for the decision model. Based on its importance, the value criterion has a 27% weight for the decision-making model.

4.4.2.2 RISK

The IT field is well known for its complexity and particularly IT projects. According to Lientz&Larssen (2006, p. 3), in the 80's, 50% of IT projects failed and only 35% resulted in tangible benefits. Also known is the fact that despite a project is concluded successfully in its implementation, several improvement issues were identified through its life. And the same issues occur repeatedly, like a pattern of issues intrinsic to IT projects. Issues like scope creep, poor organization involvement, and high stakeholder's expectations are commonly faced and known.

Bigger the number of issues higher the project risk. The more accurate the identification and address of the risk associated to a project to select, the more accurate the risk criterion score will be. This is a task lead by the PMO.

Table 26 - Types of risk issues
Source: (Lientz & Larssen, 2006)

	Internal	Teams	The work	Business Units	Management	Resistance to change
Types of issues	**External**	Vendors, Consultants, and outsourcing	Headquarters	International and subsidiaries	Technology	Business Partners
	In specific IT activities	Analysis	Software Packages	Development	Implementation	Operations and support

In the table above are some common risks. Does the project outcome will comply with regulations? Will it minimize institutional risk? As risk is a negative criterion, we must address its inclusion in the model differently. (Saaty & Sagir Ozdemir, 2003) developed specific mathematical formulas to address several negative criterions concurring for the model. To academic purposes the risk criterion should be understood not as the probability of risk existence but the probability of risk nonexistence. Therefore, a higher grade in the criterion should be valued as a low probability of risk. Based on its importance, the risk criterion has a 18.5% weight for the decision-making model.

4.4.2.3 STRATEGY •

The Strategy criterion, is built from two perspectives: Does it provide a different/distinct competitive advantage (CA), how it expects to create sustainable value in the future and how the CA itself make the product (service/software, hardware…) stands: Does it exists? Was it copied? Will the product stand long? Will it be cheaper? More factors can also be considered as CA attributes*:* cost structure, branding, product quality, distribution network, intellectual property, and customer service. For instance, a top score competitive advantage would be the development of a unique technology which could result in unique product capabilities or functionality, with potential disruptive market chances. Based on its importance, the strategy criterion has a 17.9% weight for the decision-making model.

4.4.2.4 INTANGIBLES •

IT projects intangibles identification, assessment, and quantification.

There is no clear nor a common perception that serves as standard for what is understood as intangibles. We all know that intangible is something that is nor physical and cannot be touched, but it for sure means a different thing for bus driver or for an accountant, (Vallejo-Alonso, Rodríguez, & Arregui-Ayastuy, 2011, p. 296) separates intangibles in three connotations according to the context or field they are used:

- As an economic resource, where it satisfies an entrepreneurial need, where the intangible part of the resource is more important than the material support.
- As an organizational capacity (skills and knowledge: intellectual capital, know-how, competencies, …) and
- As an accounting asset, defined by practice and regulations, hey increase or decrease (liability) the value of a company.

The most discussed and identified intangibles are Human Capital, Know-how, and Reputation. Trademark, Patents, Goodwill. An effective way to explain intangibles accounting and value to someone is to explain goodwill. It is nowadays commonly in financials balances sheets and as shown (see 3.2.3), it is the recognized overvaluation in relation to the company's value book due to its characteristics (utility, competition, ongoing and future opportunities, …). Intangibles are everywhere. I strongly believe that this awareness is a differentiation factor not only in PPM but in IT governance itself. Intangible value is hidden in the balance sheet but no in the income where its profit is detectable (Moro-Visconti, 2022, p. 54).

The IASB Framework (International Accountant Standard) considers intangibles as an asset if they can be acquired by:

a) Separate Purchase

b) Being part of a business combination

c) Government Grant

d) Exchange of assets

e) Internal Generation (Self-created)

For our model purposes, the PMO more than a search for balances and financial sheets records, should look for intangibles present in the IT project that will produce an income, whether this income is money or not, knowing that at the end all translates to money. To start harvesting for intangibles and value them to decide its model inclusion weight, let us try to split them into categories from where the company will benefit with the IT Project selection:

- Strategical (Board, Directors, main stakeholders):

Goodwill: will the company be recognized with a higher value if this specific IT project is selected? Will the IT project competitiveness grant prestige to its stakeholders, to the company? Is the project disruptive in a way that grants a commercial/production secret?

- Contract, technology-based or commercial related: Royalties, agreements, trade names and designs, natural resource rights, patented or unpatented technology rights, databases, software, code, know-how, artificial intelligence, digital media, copyright, websites, Domain Names, mobile apps, costumer's lists, customer relationships…

- External (All intangibles associated to a different external company stand)

Image: Will it be associated with a stronger quality and reliability image? Will it be associated to a bold marketing campaign? How will it be advertised? Will it create the desire for future collaborators to work in the company?

- HR:

Will it shift up HR's motivation? Will it ease their work? Will it shift up HRs education and training? Their commitment? Their ability to perform? Increase Teamwork? Will the new IT project be directly link to salary growth? Or sharable company bonuses?

- Internal (all intangibles associated to a different internal company stand)

Process Engineering (internal information flow or manufacturing flow):

Will it change how things are made? Shift Speed? Will the IT project help HRs to produce more with less effort? Will it shift production? Will it shift inner communication? Resize company to a better efficiency? Impact on the company's culture?

Always remember the model assumptions (4.2.1): Be that as it may, intangibles valuing, and appreciation will always be accounted to the decision-making model by the PMO own criteria and perception: as experienced SME's and following the strategic level directives. The identified intangibles list, in every IT project can change from a few to many, whether they are considered as an important piece of the project or not.

After its identification by categories, they should be weighted according to its consensual importance. For the decision-model purposes, based on its importance, the intangibles criterion has a 10.9% weight for the decision-making model.

4.4.2.5 SUSTAINABILITY •

In the sustainability criterion, the project is to be analyzed considering its characteristics that ensure its future life. some of several questions that must be addresses when analyzing a project sustainability:

- Resources to sustain? Is the outcome self-sustained? Will it be necessary to continuously spend to maintain? Adaptability: Can something change or adapt if unexpected situations occur?
- Will the product be made in-house?
- Is the project easy to maintain, to defects correction or incorporate new requirements?
- Will the project conduct the company to drive its business to benefits? (Not only shareholders, but the community.
- Supply the company better resources to self-growth and development.
- Local process engineering and/or product quality improvement.
- Scalability: Can the project easily accommodate growth, new software modules, expansion?
- Based on its importance, the sustainability criterion has an 8.8% weight for the decision-making model.

4.2.2.6 FLEXIBILITY

In terms of project flexibility, the assessment to make is if the project will improve the organizational capability to effectively respond to changes, whether these changes are internal or exogenous to the company. The organization is always under the possibility of change at the structure, procedures, technology, and culture. Example of IT Project contribution to flexibility are the creation of new service models (costumers tend to change their relationship to the product or the company when they change product (new maintenance habits, new schedules, new processes, and the company must foresee and offer its services based to that change), or a new software that impacts in the supply chain or stock management processes. A software developed in-house normally tends to be higher ranked than a COTS solution in this criterion exactly because if quick changes are needed it is usually faster and tailored to react to software upgrades if they are built by a company's programming team. Flexible IT projects are adapted to rapidly changing environments and with a higher opportunity readiness. Based on its importance, the flexibility criterion has an 8.5% weight for the decision-making model.

4.4.2.7 CREATIVITY

Are we facing new innovations? Does the project change the way the company works if it is chosen to invest in? Will the IT project implementation allow to produce new disruptive products, or does it address workflows in a new creative or disruptive way? How high are the R&D expenditure costs associated to the project? High? So, it indicates creativity. New product? New costumers? Will it innovate time to market (from thinking a product to its arrival to the market)? Will the project allow employees to allocate more time to the creative process? Based on its importance, the strategy criterion has an 8.4% weight for the decision-making model.

4.5 PHASE FIVE - SELECT IT PROJECT

At this stage, we have a deep knowledge and understanding of the IT Project submitted to the model. The existent criteria of the project were identified and evaluated by the strategic point of view and the model rules. The extension of the number of the projects that belong to the portfolio will determine how the comparison is made: Or the project is analyzed alone, scored, and compared by its final grade, or, if for example the decision is to be made from only two projects, projects can be compared criterion by criterion. The final grade should be the same whether path 1 or 2 is pursued, but a more sensitive analysis is achieved through the second option.

This phase ends when the PMO finally identifies the IT Project to invest in, and then submitted to the board of directors for its approval. With this deliverable, it ends the main responsibility of the PMO in the process. The next phase can be delegated by the board to the PMO responsibility, if competences

and the expertise to this matter is installed in the PMO, but normally the PMO has as attribution the project selection and forwards, its implementation and lifecycle management.

4.6 Phase Six - Vendors Evaluation or in house development

A major step towards the IT project conclusion is the decision of how it will be developed. To deploy an IT solution requires mainly to choose between two options: to build a solution at a cost that implies the use of internal human and capital resources, or a purchased one. It can be a time-consuming process: better requisites are defined, less time to toss away. This is important because normally there is not only one solution in the market nor a single vendor. The aim is to narrow the options. In the table there are some advantages and disadvantages of to build and buy options:

Table 27 - Inner or outer development – comparison

	Advantages	Disadvantages
Build in-house	• Custom made, tailored to the business need • Better culture understanding by the developers • Internal knowledge	• Expensive • Time consuming • Present suitable but in the future?
Buy (vendor)	• Initial ease of deployment • Ongoing support • Ongoing development (widely tested, wider range of users) • Ux more friendly • Reduced costs • Direct access to specialists	• Expensive SLA's • Communication issues • Security problems (business intel may be exposed)

Nevertheless, a vendor should not be picked exclusively based on a proposal evaluation/request for information. The vendor itself should be evaluated. It is a known vendor in the market? Do we have customer feedback? Do we have previous business relationship with him? If so, it is a candidate. To the identified candidates a request for information about the solution is sent.

4.7 PHASE SEVEN - FINAL DECISION

So, we did a need analysis, picked a project that aims to respond to the identified needs, decide if the organization want and can develop the project or if it is outsourced. For the last option, the request for information is sent. The vendors that more accurately respond to the organization solution needs in the request for information will receive a request for proposal. From the pool of proposals answered, the one that meets more requirements with high priority is selected. Well, it should be like this but the circumstances of the establishment of a formal contract with a vendor may be subject to national legal frames that requires previous request for proposals to be sent in the form of a contest and the selection made under criterions expressed in the contest rules, for example, the cost.

5. PRACTICAL CASE: IT PROJECT SELECTION FROM A PORTFOLIO. HOW TO USE DE MODEL

To test our model, a portfolio with two IT projects is created/simulated, for the follow organization:

i. *GMS* Organization: GMS (fig.14), is a merchant navy that is based in Lisbon, Portugal, and as trade routes with 23 different ports of 15 different countries. The cargo are mainly containers and energy production wind towers parts. As a solid, sustained, and well-established company, GMS has its own school, where it trains its sailors and future ship captains.

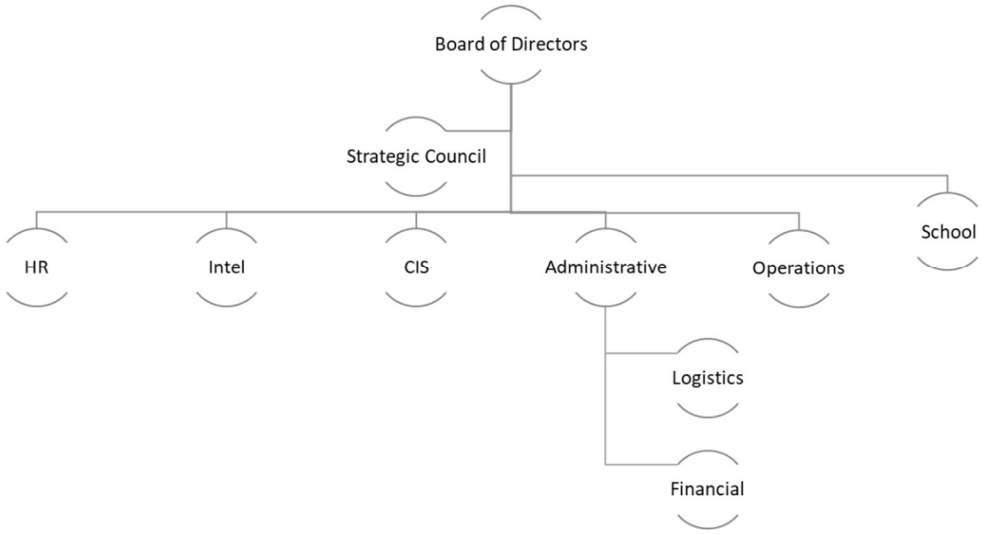

Figure 14 - GMS Organization

ii. GMS Mission: To deliver better, faster, anywhere, across the sea.

iii. GMS Vision: To be nº1 Merchant Carrier Navy in Europe.

iv. The portfolio: The GMS CSI department and the board have identified two technological gaps that need to be addressed. The first stands for sanitary purposes: health care treatments to the sailors at sea. The second stands for education and training: to replace an obsolete scholar management system. Next, both projects are analyzed in detail and evaluated under the decision-making module.

5.1 PROJECT 1 - SCP – SINGLE CLINICAL POST

5.1.1 General Data

Table 28 - SCP Project scope

Project Name	SCP – Single Clinical Post
Needs Identification	Implement a software to support SCP HR Health Care
Motivation for the new solution	Manage the collaborators Health Care environment, with the follow categories impact: Technology, Administration, HR, Finances, Logistics, and operations.
Stakeholders	Board of Directors, Medical staff, Nursing staff, administrative staff, HR staff, Financial Staff, Information System staff and partner clinic
Goal for de adoption of the new solution	The system should be able of managing all sailor's clinic data, at sea, backup it locally and ashore at GMS and synchronize it with the partner clinic.
Budget	267000€

At sea there is not available an IT solution to ease nursing and medical care. The history of treatments was not recorded for later accounting and clinical follow-up. A MoU (Memorandum of Understanding) allowed to establish a protocol between GMS and a Health clinic in Lisbon that will record all GMS employee's data and clinical updates. Objective: updated personnel clinical status, on-board and at the clinic, ashore.

The information system requirements (macro):

- Allow information consultation on board, updated before transit start, in-port, or trough satellite GSM service, of sailor's clinical information and clinical gear and pharmaceutical goods stock records, with the main server ashore.

- To an effective mission of on-board information, the system should allow to identify the list of the members of the ship's garrison, and from it to obtain each element clinical status from the main server ashore, to subsequent on-board consultation.
- It should allow offline work, with further synchronization with the connection establishment at the network availability and/or at the mission end.
- The clinical information record must be able to generate alerts to be shared among SCP clinical professionals.
- At the travel carrier mission completion, clinical information must be updated and synchronized with the ashore servers.
- It must allow to determine a medical discharge of clinical processes, whether they start in the mission or before.
- The system must prioritize sailor's follow-up medical appointments, in emergency cases or urgent medical needs.
- Is must allow the consultation of clinical and pharmaceuticals materials offline, their consumption records and update this information at the mission completion.
- To grant a user authentication access based with GMS active directory, with the *need-to-know* information access principle.
- To separate clinical information by medical specialties (eg. The psychological evaluation record of a sailor only should be accessed by other doctors than a psychologist if they have higher system privileges or by medical justified need).

Contract management (if decided to outsource):

- The vendor must guarantee all installation, assembly, and configuration of the proposed IT solution.
- During the term of the contract, the vendor must maintain the appropriate resources, know-how and technical experience appropriate to the service to be provided, to always guarantee the indispensable support in terms of technical assistance, maintenance, updates, and development.

- The vendor should keep GMS informed of the platform roadmap and manufacturer's recommendations on future developments and products under development, as well as the costs involved to implement them in GMS' infrastructure, whenever possible, and an impact assessment of their implementation, so that a cost/benefit ratio of the solution for ships can be established.
- The vendor must establish a detailed education & training plan, to all GSM medical and nursing staff.

These are the main project characteristics. Further detailed aspects of the project are highlighted along way as the decision-making model is applied.

5.1.2 Application of the model

So, the define criteria is known. The IT project must be evaluated under the 7 criterions. The first is Value.

Strategic alignment and financial attractiveness. A project has is top grade when it is fundamental and directly impacts the company's business. An IT solution that is related to the HR wellbeing, with impact in its collaborators health end following is important. Considering that sailors are one of the most crucial parts of GMS business because they are the ones that carry its main mission by delivering cargo, crossing seas. A bad health management can have unpredicted costs. But will GMS stop if sailors do not have their clinical record up to date when they dock at any given port? It won´t. Can the follow up be unprecise leading to future sailor temporary or permanent unavailability? Yes.

Financial attractiveness

Considering an initial investment of 250000, with a discount rate of 5%

Table 29 - SCP NPV

Rate	**0.05**					
Year	0	1	2	3	4	5
Cash flow	250000	50000	60000	70000	70000	80000

So, applying NPV calculation

$$NPV = \frac{Cash\ Flows}{(1-i)^t} - Initial\ Investment$$

NPV=41,007.74€. A worthwhile endeavor.

IRR:

Table 30 – Internal Rate of Return

Period	Valor
1 (initial investment)	-250000€
2	50000€
3	60000€
4	70000€
5	70000€
6	80000€
IRR	**9%**

TCO:

Table 31 – Total Cost of Ownership

21. INFRASTRUCTURE COMPONENT	22. COST COMPONENTS
Hardware acquisition	25000€
Software acquisition	75000€
Installation	61362,30€
Training	15000€
Support	15017,33€
Maintenance	10000€
Infrastructure	25000€
Taxes	0.23
Residual Value / Resale Value	80000
TCO	1860148

BCR: 330000/186148= 1.77 >1 Positive NPV.

The SCP IT project shows predicted strong financial data, so with high score evaluation. In the value criterion, the total attribution of the 27 percentage points will be distributed in a 60-40 to the strategic alignment preference. So, a full aligned project should have 0.60*0.27 and a perfect financial attractive project 0.4*0.27. In this case, considering SCP as partially aligned (it is not crucial to the main mission) and the particularly good financial attractiveness, the value criterion will be scored with 60% in strategic alignment and 90% in financial attractiveness. For the AHP decision-making model, project SCP stands with [(0.6*0.6) + (0.9*0.4)] =0.72 of 0,27 criterion model weight = 0.1944% score.

RISK

The risk of SCP can be of the most importance to project failure if no addressed prior to execution in the portfolio decision phase (3rd and 4th of the decision roadmap). The risks associated to SCP that were identified are depicted in table 32:

Table 32 - SCP project risks

RISK	SCOPE	DESCRIPTION
Time	Time	The installation of the infrastructure and workstations on board can be time-consuming given the vessels availability.
User's	HR	The resistance to change may delay the GMS Health staff to fully explore the SCP
integration	IT	IT integration complexity with the 3 site deploys and synchronization.
Cost	Logistics	The risk of a vessel unavailability due to SCP installation and configuration and training is high.
Stakeholders	Communication	The communication management is crucial to the success of the project. Though engaged, the fact that the main servers ashore are under different administrations may difficult stakeholders (GMS, Private Clinic, and vessels) to maintain an active issues discussion.

As SCP is not a project with direct impact on GMS mission so by itself, this definition lowers the risk in a big way. One of the overcome of its failure, could be unexpected sailors' unavailability, or by health condition misjudgment or by time waste of clinical procedures (administrative or not) that could be eased by the project and made for example at the sea, in transit. Remembering the negative criterion, the risk is evaluated by not the existence of risk but the probability of risk nonexistence. Facing a 30% risk, there is 70% probability that risk will be non-existent or mitigated. So, to the risk criterion scores (0,7*18.5%) =12.95%.

STRATEGY

The SCP is a project that will stand long in GMS if chosen to invest. Investment in health and clinical follow of a company's HR's is always important for care services and to assure an important part of the organization operationality, that is HR labor, so it is understood that SCP is a solution that will stand long. It has a minor competitive advantage, which is improved efficiency regarding HR's health follow up. A key factor is facing the GMS budget, will the SCP be developed in-house or outsourced or purchased. If developed by its own means, the intellectual property and the possibility of future solution reselling would increase the strategic importance of the project. Considering that a disruptive project should be highly scored (above 80/90%) and that the absence of an IT solution with SCP functionalities is not GMS business imperative, I will consider a 60% weight within the criterion. So, the SCP strategy criterion scores (0,6*17.9) = 10.74.

INTANGIBLES

The intangibles criterion must be looked at as the appreciation of the project advantages that are not easily measured but considered important with the entry SCP in production. In the table 33 intangibles associated to SCP implementation and exploitation are listed.

Table 33 - SCP Intangibles

SCP Intangibles		
Strategical	Goodwill	A company known to care to its collaborator's health is recognized pairwise and a banner in terms of recruitment; All endeavors to improve efficiency are appreciated and valued, including market wise.
		The establishment of a protocol with an external health, or any external relationship directly linked to the business or not grants prestige and value to the company.
Tactical	Technology	The development in-house of SCP can open a door to commercialize SCP to other maritime cargo companies. It would shift GMS market value if the GMS board decided so.
		Software, code, know-how, SCP mobile
	Image	Stronger external image
Operational	HR	HR satisfaction
		Clinical staff eased work
		The SCP availability impacts in staff health concern culture with closer following and easy access
	Processes	Change in how clinical personnel status is followed and made. Any process updates assurance. Speed shift by internal and external synchronization.
	Production	To have an updated clinical follow-up of sailors directly impacts in their availability to sail, so it boosts staff operational availability.
		Increased staff availability impacts in lower docking times. Docking time is expensive in port fees and charges.

Based on its impact in the organization, SCP is scored with a 7 out of 10, so (07*10.9) gives a final 7,63 criterion weight.

SUSTAINABILITY

The SCP project is a project that will last. The maritime merchant business will need for a prolonged period, sailors, and the strategic importance of their operational status and availability is huge.

Financially, the annual maintenance is estimated of 10000€/year, plus the hardware and computers/tablets OS software updates. This maintenance fee assures that unforeseen health events such COVID-19 bureaucratic treatment can be added to the SCP features, so SCP adapts easily. If developed in-house the cost maintenance is HR's work, it´s scalability given. For an in-house development, this project scores 100% sustainability, so 8.8% in the model criterion weight.

FLEXIBILITY

SCP is not a determinant project regarding the GMS mission, as previously explained. Though its tangible and intangible impact are considerable, it does not participate in an effective response to external market change need in the same amount. Internally GMS is still a maritime merchant cargo transportation, and its core business will remain so. Still, it is a flexible solution, easily updated. As we are considering flexibility, SCP scores 90% in the model criterion weight.

CREATIVITY

SCP is a creative project. Probably it exists in the market, but it is unknown to me that there are maritime cargo companies with synchronized medical and clinical software at sea and ashore in the company and in the protocoled health clinic. The fact that the record is always updated, with ashore appointments schedule facility to follow a sailor's condition when his ship docks in the clinic, for instance the medicine booking in the clinic pharmacy in case of stock failure on board are, at my knowledge, examples of innovative features of the SCP. Based on its creative importance, SCP has 90% criterion weight. Depicted (fig.15) we can see the global SCP criterion entry model evaluation:

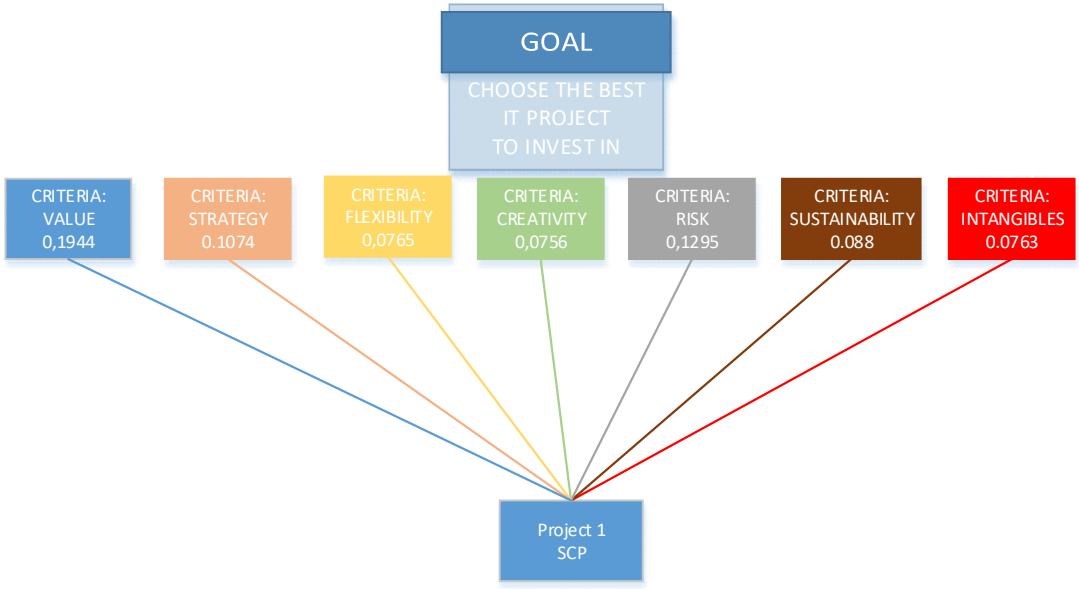

Figure 15 - Global SCP criterion stands

5.2 PROJECT 2 – SMS – SCHOOL MANAGEMENT SYSTEM

5.2.1 General Data

Table 34 - SMS Project Scope

Project Name	SMS – School Management System
Needs Identification	Implement a software to support GMS School
Motivation for the new solution	Manage GMS School administrative operations.
Stakeholders	Board of Directors, GMS teachers, GMS students (future captains and sailors), administrative staff, HR staff, Financial Staff, and Information System staff
Goal for de adoption of the new solution	The system should be able of managing all GMS school administrative tasks, such as schedule management (professors and students), classroom management, discipline management school HR management (presences, absences, leaves, school holidays), grades publishing and conferences management.
Budget	250000€

The school plays a significant role on GMS business and external prestige. The school has in its student body not only the future captains and sailors of GMS merchant vessels, but also external students that pay for naval arts, welding, seafaring, marine mechanics, marine systems electronics, International Maritime Organization rules, Maritime Law. Inclusive pleasure boating licenses need previous education and training available at GMS.

Facing the demand and the school strategic importance, GMS needs an IT solution to do the entire scholar management. Teachers and students' management, schedules, facilities, scholar grades, etc. It is perceived by the board and the GMS academic community that the existent system is out-of-date, and some complaints are arising. The project has two implementation phases: Mapping (Functional requirements and Business Process Model and Notation) and system development and implementation.

The information system requisites (macro):

- Functional Requisites Mapping – Based in a business architecture methodology, it will clarify the principles needed to the system governance, its future evolution and maintenance to build, maintain and update a database shared by the stakeholders. At the end a vision of the system governance, de process architecture, the information architecture and the supporting apps, the technology is achieved.

The SMS will encompass:

- Scholar Management module:

- Courses characterization
- Courses Management (Create, edit, delete).

- Schedule Management Module

- Classroom management.
- Education support materials management.
- Teachers' management.
- Students' Management.
- Schedule Management.
- Visits, internships, and seminars management.

- Questionnaires Management

- BPMN – Each developed module/process must be, as a deliverable, followed by its business process representation. At the end, all information flows of the SMS must be depicted, accounted, and provided.

These are the main project characteristics. Further detailed aspects of the project are highlighted along way as the decision-making model is applied.

5.2.2 Applied model

Strategic alignment. GMS vision of growth cannot be disassociated from a strong education & training HR program. Known that for every organization HRs are their main asset, to train and shape actual and future collaborators to its design is of crucial importance. As mentioned before associated to its internal endeavour, external students (students not recruited to GMS work body/staff) play a vital role in the certification of GMS's educational programs quality and prestige. So, to have a CIS new solution to boost the school mission efficiency was well accepted and encouraged by the board.

Considering an initial investment of 250000, with a discount rate of 6%

Table 35 – Annual Project Investment
source: (author)

Rate	**0.06**					
Year	0	1	2	3	4	5
Cash flow	250000	60000	70000	70000	70000	70000

So, applying NPV calculation

$$NPV = \frac{Cash\ Flows}{(1-i)^t} - Initial\ Investment$$

NPV=35,431.50€. As SMS also pays back.

IRR:

Table 36 – SMS Internal Rate of Return

Period	**Valor**
1 (initial investment)	-250000€
2	60000€
3	70000€
4	70000€
5	70000€
6	70000€
IRR	**10%**

TCO

Table 37 – SMS Total Cost of Ownership

INFRASTRUCTURE COMPONENT	COST COMPONENTS
Hardware acquisition	10000€
Software acquisition	150000€
Installation	30231,30€
Training	27000€
Support	12033€
Maintenance	7500€
Infrastructure	25000€
Taxes	0.23
Residual Value / Resale Value	50000
TCO	163059

BCR: 340000/163059= 2.08 >1 Positive NPV.

The SMS is an expensive software. But all the financial data about the project shows strong indicators. The GMS strategic council predicts further school income if SMS is chosen to invest. The ability to process the academic community with mor efficiency, its increased general satisfaction and eased GMS premises management, will boost incomes and gather more students do the school. To the model, is considered an 80% value weight and a 90% financial attractiveness. [(0.8 *0.6) +(09*0.4)] = 84% of the model criterion weight.

Risk

Table 38 - SMS project risks

RISK	SCOPE	DESCRIPTION
Scope	Development	Given the multitude of modules and features intended for the SMS, a failure in the scope definition and the BPMN information collection can extend and skew the project production entry, becoming user unsatisfying
Time	Time	A large scope IT solution tends to become a time-consuming project.
User's	HR	The resistance to change may delay the SMS exploitation. If not user friendly, practical and task oriented, it can be "rejected." To guarantee school ongoing tasks, the old IT software will work in parallel with SMS until its completion
Cost	Financial	Given the existence of a prior software, though obsolete, it is an obstacle to SMS acceptance. Facing the potential financial investment in SMS, GMS must decide the old software shutdown when SMS enters in production. This is a potential risk in case of SMS poor acceptance.

SMS contributes to GSM mission in the proportion of the contribution of education & training to it. But, though less efficient, the old obsolete software still works. In other words, GMS wouldn´t stop if SMS is not chosen as an investment, but for sure less driven to better educational efforts. At the end, the bigger risk is the financial investment that can be loss. So, facing a 40% probability of some identified risks will occur, there is a 60% that they will be non-existent or mitigated. The criterion scores 0.6 % of the 18.5 weight in the model.

Strategy

We cannot consider that SMS is a competitive advantage in the way that GMS would be in front or higher ranked compared to other related schools. It does create a sustainable value for the future, where a more efficient school, with an increased satisfied academic community, better feedback, better work processes, better information flows as impact in education & training quality and reputation. A company's good reputation can attract new customers. SMS as a scalable architecture design, so it is easily updated before predicted or unforeseen changes. SMS must be analysed not as a distinct market IT scholar solution, but as a tailored scholar solution that will boost school contribution to GMS´s mission. It is considered a 70% weight within the criterion.

Intangibles

Depicted in table 39, some identified intangibles to be accounted in the SMS IT Project:

Table 39 - SMS Intangibles

SMS Intangibles		
strategical	Goodwill	If there is a characteristic with an obvious relation to goodwill is prestige. To have a prestigious school is also related to how the school works. Less coordination and management issues, shows a professionalism image. A scholar good reputation attracts new students, new professors, new work candidates.
		With increased scholar processing capabilities, GMS can open its school to other companies and provide education & training to other entities.
	Image	Stronger external image
Operational	HR	HR satisfaction
		staff eased work, increased performance
		SMS education & training
		Intellectual Capital, Know-how
	Processes	Increased efficiency. Increased bureaucratic time response
		Increased staff availability impacts in lower docking times. Docking time is expensive in port fees and charges.
	Technology	New school website, school mobile app
Tactical	Costumer	Costumer Relationship

Based on its impact in the organization, SMS is scored with a 7 out of 10, so 70% of the intangible's criterion weight.

Sustainability

Scholar IT systems usually do not matter do the board as mission operation systems do. For obvious reasons. Normally an investment in a school management software tends to be initial expensive, but last for long. The only concern is that the solution is scalable and easily updated. This educational area does not use to suffer structural changes, so preventing the aforementioned features should guarantee the SMS adaptability. The project SMS impacts not only on stakeholders but also in the entire GMS academic community. SMS IT project scores a 100% sustainability, so the total of the 8.8% criterion weight.

Flexibility

SMS has its ability to respond to external changes in part. If the environment dictates that education & training should focus in new areas, it can be easily reverted to GMS scholar doctrine. If GMS board will define that a certain kind of response in its mission and business can be given trough HR education & training, it will be more prepared with a new and modern scholar management software. The only if is that a software with this magnitude is so time consuming to develop that has a higher probability to be acquired and outsourced. This decision lowers the flexibility score to 80% in the model criterion weight.

Creativity

An IT project of a software for school management purposes hardly is a highly creative project. Is this criterion when can attribute some points based on the time saved by the school employees in their daily task, with higher performance, to spend in other creative activities, to the school mission cause. Some innovations can be identified, in feature A or B, but not enough for a big score. Based on its creative importance, SMS has 10% of the creativity criterion weight. Depicted in fig.16, we can see the global SMS criterion entry model evaluation:

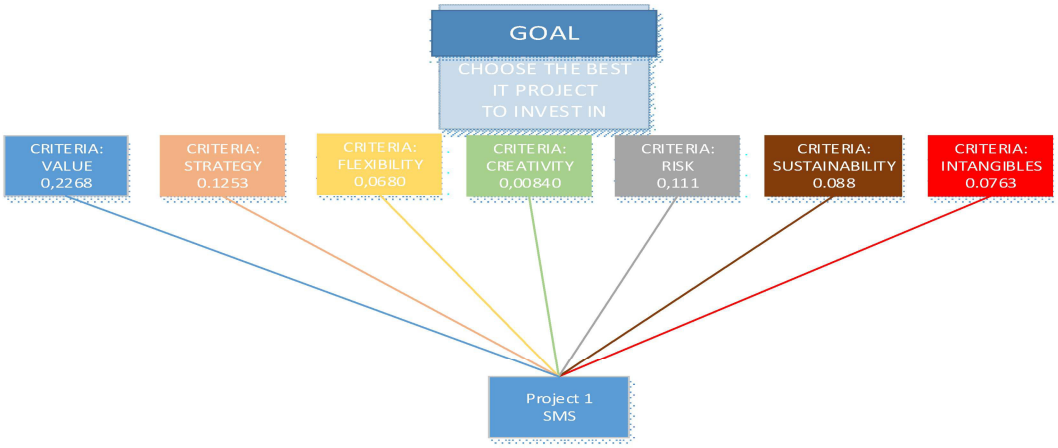

Figure 16 - Global SMS criterion stands

Combining both projects score in a matrix (table 40):

Table 40 - Final projects criterion score

	Value	Strategy	Flexibility	Creativity	Risk	Sustainability	Intangibles
SCP	0.1944	0.1074	0.0765	0.0756	0.1295	0.0880	0.0763
SMS	0.2268	0.1253	0.0680	0.0084	0.1110	0.0880	0.0763

Converting the data to establish the simple multiplication of the matrixes (fig.17) with each project score and the criterion weights, we can extract the final grade for the projects:

$$\begin{bmatrix} 0,72 & 0,6 & 0,9 & 0,9 & 0,7 & 1 & 0,7 \\ 0,84 & 0,7 & 0,8 & 0,1 & 0,6 & 1 & 0,7 \end{bmatrix} * \begin{bmatrix} 0,27 \\ 0,179 \\ 0,085 \\ 0,084 \\ 0,185 \\ 0,88 \\ 0,109 \end{bmatrix} = \begin{bmatrix} 1,5397 \\ 1,4958 \end{bmatrix}$$

Figure 17 - Final projects score

The decision-making model result: Project SCP has the higher score with 1.54, so a stronger fulfilment of the board´s vision. In the case of a limited budget and forced to decide for only one of the suggested projects, GMS should start by investing in SCP.

6. CONCLUSIONS

This chapter concludes this dissertation with an overall final consideration of the developed work, its goals and objectives, limitations and appointing a potential future line of work.

6.1 RESEARCH QUESTIONS AND AIM

Research Questions: In answer to the first research question, AHP was the decision-making model that served as basis to the artifact of the thesis. Its handling of qualitative data allowed the possibility of the quantification of intangibles. Regarding the second research question, the answer drove to the basis of the proposed decision-making model that highlights as the main IT project characteristics when choosing an IT Project to invest from the portfolio, that have been poured in to the criterions of the model: value, intangibles, all the characteristic of the project that boost flexibility, creativity, sustainability, lower the risk and last but not the least, aligned with the company strategy. We saw, in answer of the third research question that intangibles can be accounted in decision-making models.

AIM: In the first chapter, three challenges were issued, translated in three objectives: first to identify decision-making models. They were. Talked about several, two explained in detail: TOPSIS and AHP, with AHP selected as the one to serve as a basis to the study goal. Second, when the appraisal of the main IT project characteristics, we entered also in the intangibles sphere: not only tangibles important characteristics were named, but also the importance of the identification of the intangible ones that could bring importance and profit to the business. Last but not the least, the construction of a decision-making model that could embrace the intangibles appreciation and quantification, allowing a better IT project understanding and valuation.

Second intangibles: they are hard to identify, harder to quantify and even harder to establish a relationship between their existence and their contribution to the company's mission. But I hope that the readers found and acknowledge that not only they are important to the organization and to its collaborators, but they can be determinant in a choice between two IT projects.

As any decision model, it started with the problem identification. After that we have a problem, a decision criterion is to be established. The criteria are based on strategic defined criterions, with its importance established by the decision makers (strategic board/council, PMO, department heads…), translated to weights. Alternatives are developed, analyzed, selected to finally implement the decision.

Two things though, must be always addressed when dealing with criteria, criterion alternatives and intangibles: first, the criteria selection for achieving the goal must be defined at the higher levels of the organization to assure that what is to be considered and appreciated in a given IT project candidate is

weighted accordingly with the organization mission and the board's vision. Like this, a high scored project means that its contribution to the organization's business is proportional to its score. In the case study were defined 7 criterions of importance, but others can be defined if considered more important.

As a synthesis of the developed work, the issue was to endorse intangibles in a mathematical decision-model to the selection of an IT project in a portfolio context. The work proved that the AHP was a model easily adapted to the task, for its simplicity and possibility que quantify and turn qualitative data (intangibles) to quantitative data. The Saaty's scale to address such phenomenon and its conversion to a mathematical matrix, with its proven consistency, helped the task.

6.2 LIMITATIONS

One of the work's limitations was the extent of analysis that an IT project investment requires. The exposed practical cases were merely examples, and for instance only the analysis of the value and the risk criterions of the model would serve as a dissertation thesis.

Secondly, the criteria definition. The definition of which criterions should be chosen and the weight of each criterion to the model are debatable, arguable. Tens of criterions more could be chosen and accounted for different strategic levels of the organizations. Though narrowed the scope to the IT environment, a lot more criterions could be of more importance for companies. The aim was always as an example and to academic purposes.

Third, the work stated for a methodology that produced a decision-making model, not an absolute law or doctrine. It gives a line of thinking, a way to calculate benefits over costs and to appreciate the mostly forgiven project intangibles and incorporate them in the calculus.

6.3 FUTURE WORK

It can be suggested several interesting future development suggestions:

- First the exploration of the criterions. Each criterion can be deeper analyzed. A book with the model and a chapter for each criterion.
- Intangibles: further identification and maybe a different way of its inclusion in the model.

- Different methodology: within the same context, that is the IT project selection in a portfolio, a different approach to establish the most indicate project to be chosen to investment, but now not in AHP

- A practical case in the real world. To apply the proposed model to a portfolio of real projects and to establish a cause-effect with decision-making model with the observed profits and success of the projects.

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