Facilitate the adoption of TDABC

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Resumo

A eficiência de custos foi sempre um dos focos principais das organizações, particularmente nestes últimos anos após a crise económica. Posto isto, a sua relevância tem vindo a aumentar devido à pressão do mercado para manter margens de lucro praticando, ao mesmo tempo, preços baixos. Contudo, embora a transparência de custos seja uma das principais preocupações das organizações, as mais recentes metodologias de custeio, como o TDABC, têm altos custos de implementação, não convencendo os gestores dos benefícios da sua adoção. Com isso em mente, a nossa proposta para esta tese é de facilitar a adoção do TDABC reduzindo os seus custos de implementação. Para atingir este objetivo, propomos o uso de modelos de custeio de processos baseados em *frameworks*. A nossa proposta foi posta em prática através de uma demonstração numa organização e avaliada por especialistas em entrevistas com questionários, através dos princípios da *Moody and Shanks Framework* e princípios de Österle. Em suma, esta tese foi capaz de propor uma solução que dá um passo no sentido de aumentar a adoção do TDABC. Com base nos resultados apresentados, mostrámos que o tempo de implementação pode ser reduzido e, consequentemente, o seu custo. Além disso, acreditamos que esta proposta tem o potencial de alavancar os benefícios do TDABC, facilitando sua implementação e abrindo o caminho para a criação de uma *Framework* de modelos de custeio de processos.

Palavras-Chave: TDABC, Modelos de custeio de processos, *Frameworks* de Processos, CMMI

Abstract

The pursuit for cost efficiency has always been of extreme importance for organizations and, particularly in these recent years after the economic crisis, its relevance has increased due to market pressure for keeping profit margins and low product prices. However, even though cost transparency has been one of organizations' major concerns, the most recent costing methodologies, like TDABC, have high implementation costs that do not convince the decision makers to be worth the outcomes. With that in mind, we propose with this work a way to facilitate the adoption of TDABC and, at the same time, reduce its implementation cost using framework based process cost templates. Our proposal was demonstrated through a field implementation and evaluated by experts in interviews and closes-ended questionnaire, using the Moody and Shanks Framework and Österle principles. All in all, this research was able to propose a solution that can be a step towards increasing the adoption of TDABC based on results that showed it can reduce the time of implementation and therefore its cost. Furthermore, we believe this proposal has the potential to leverage the benefits of TDABC by facilitating its implementation and be the laying ground for a framework focused on cost process templates.

Keywords: TDABC, Process cost Templates, Cost Awareness, Process Frameworks, CMMI

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List of Acronyms

IT	Information Technology
ABC	Activity Based Costing
TDABC	Time Driven Activity Based Costing
DSRM	Design Science Research Methodology
CCR	Capacity Cost Rate
CMMI	Capability Maturity Model Integration
COBIT	Control Objectives for Information and Related Technologies

Chapter 1

1. Introduction

The present global economic context, defined by a global free market, is forcing companies to rethink the away they satisfy the demands of their customers. The competitive market environment forces companies to deliver low price innovative products thus reducing their profit margins. In face of this problem, organizations are realizing that cost awareness and cost analysis are essential to maximize profits.

The way cost awareness is practiced has been changing through the years specially since automation started to change organization's principal costs from direct labour and direct materials to indirect cost and back office. The proportion of overhead costs in companies increased from 10% to 40% between 1950s and today. Furthermore, as it was mentioned before, the pressure competitors hold over each other forces organizations to extend cost efficiency to their operations thus making the more complex organizations, that deal with huge overhead departments, to feel more difficulties achieving the required level of operational effectiveness [1].

For a manager to be able to put in place the appropriate measures and to achieve the abovementioned level of cost efficiency the organization needs to have access to the information of how costs are distributed. In order to obtain this information several cost methodologies were developed. Even though having this information is a competitive advantage for the organizations, the cost of applying these methodologies and correspondent costing tools is still too big for some manager to see it as worth the investment [2]. Furthermore, there are still a lot of methodologies that are not appropriate for the new organizational paradigm dominated by overhead costs.

The methodology we are going to analyse is Time Driven Activity Based Costing (TDABC), a version that eliminates some problems of the previous Activity Based Costing (ABC) model but is still considered as a bad investment for a lot of managers [2]. TDABC arose from the low rate of adoption, disappointment, uncertainty and dissatisfaction that surrounded ABC [3]. Although it represents a better version of ABC and has been successfully implemented in some small, medium, and large

private and public companies, the truth is that the adoption rate of TDABC is turning out to be even lower than that of the ABC methodology [3]. With that in mind, we focused our research in developing a proposal that aims to help solving this low adoption. Therefore, our proposal consists in the use of process cost templates and framework guidelines to implement TDABC on an organization by the means of a cost analysis service [4].

This research is going to follow the iterative methodology of Design Science Research (DSRM) [5] [6] and is going to be built around the guidelines established by that same methodology. In the first place, we are going to describe the abovementioned research method (chapter 2). Afterwards, we proceed describing the identified problem (chapter 3), we define the motivation of the research followed by a motivational demonstrations and brief description of the solution and, finally, we specify the research questions. After all this, we describe the state of the art of costing methodologies, TDABC implementation guidelines, costing templates and costing tools (chapter 4). Moreover, we will describe our proposal to solve the identified problem (chapter 5) and demonstrate it in an organization (chapter 6). Finally, we will present our evaluation procedure and criteria (chapter 7) followed by the lessons learned (chapter 8) and conclusion (chapter 9).

Chapter 2

2. Research Methodology

This section intends to explain the chosen research methodology and the arguments that justify such choice. The research methodology chosen was Design Science Research Methodology (DSRM) [5] [6].

The Information Systems research community has the responsibility to produce knowledge that supports the implementation of IT to organizations. Acquiring this knowledge involves two distinct paradigms, behavioural science and design science [7]. The first concept is a paradigm that has its roots in natural science research methods. It seeks to develop and justify theories (i.e., principles and laws) that explain or predict organizational and human phenomena surrounding the analysis, design, implementation, management, and use of information systems [5]. The second concept, Design Science, is the basis for the used methodology and has its roots in engineering and the sciences of the artificial [8]. This paradigm focuses on solving problems, create innovations for specific field problems. Furthermore, it established an iterative research strategy that is based on a systematically reviewed literature [9].

DSRM consists on an iterative methodology based on the Design Science research principles outlined by Hevner et. al [5]. This iterative methodology is a process model composed of six well defined activities [6] that help researchers conduct design science research (see fig.1). These DSRM activities are detailed below [6].

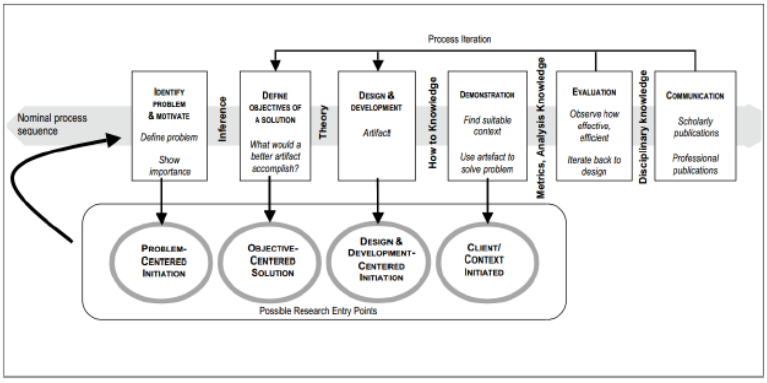


Figure 1- DSRM Process Model [6]

Activity 1: Problem identification and motivation. Aims to specify the research problem and justify the value of a solution. It may be useful to atomize the problem concept so that the solution is able to cover all its complexity. This solution must be provided by the artefact developed on top of the problem definition. The solution value proposition is an important part of this step. The proposal should be able to motivate the researchers and the respective audience to accept the results and the solution, as well as the researcher's problem perspective. This activity corresponds to the Introduction, Problem and Related work (sections 1, 3 and 4).

Activity 2: Define the objectives for a solution. This step aims to define the objectives the solution is supposed to achieve. Those objectives must consider the problem definition and knowledge of what is possible and feasible. They can be quantitative and qualitative. The first ones, show how the pursued solution is better than the current ones. The qualitative objectives can be descriptions of how the artefact is supposed to support solutions for problems not yet addressed. For this step, knowledge about the problems and the current solutions is required. This activity corresponds to the Introduction and Problem (sections 1 and 3).

Activity 3: Design and development. This step focuses particularly on creating the artefacts. These artefacts can be models (e.g. representations and abstractions), methods (e.g. algorithms and practices), instantiations (e.g. implemented and prototype systems) or constructs (e.g. vocabulary and symbols) [5]. The artefact of this research is a method. In order to develop it we need to analyse the related work, the theoretical basis available and address the main faults of TDABC and the ways its being implemented. This activity corresponds to the Proposal (section 5).

Activity 4: Demonstration. This step intends to demonstrate the usefulness of the artefact to solve one or more instances of the problem. This demonstration could involve, experimentation, simulation, proof or case study. This activity corresponds to the future demonstration (section 6).

Activity 5: Evaluation. This step focuses on observing and measuring how well the artefact supports a solution to the problem. It involves comparing the defined objectives of the solution with the observed results the artefact is able to provide. This comparison can be done in many ways, *"It could include items such as a comparison of the artefact's functionality with the solution objectives from*

activity 2, objective quantitative performance measures such as budgets or items produced, the results of satisfaction surveys, client feedback, or simulations. It could include quantifiable measures of system performance, such as response time or availability. Conceptually, such evaluation could include any appropriate empirical evidence or logical proof." [6]. If the results do not meet the expectations a reiteration of the activity 3 can be done. This activity corresponds to the Evaluation (section 7).

Activity 6. Communication. The final step consists in communicating to the research community, the problem, its importance and how the artefact is able to provide a solution. This allows the work to get accreditation and approval from the community in the field. This can be achieved mainly by academic publications. This activity corresponds to Communication (section 8).

The DSRM Process model requires that all those steps are done sequentially in order to achieve the objectives. Although, the process can have several entry points:

1. **Problem-centred** – when the work starts from the problem identification and motivation step.
2. **Objective-centred** – when the work starts from the definitions of objectives step.
3. **Design and Development centred** - when the work starts from the Design and development step.
4. **Client/Context initiated** - when the work starts from the Evaluation step, meaning an evaluation about an already applied solution needs to be done.

In our research the DSRM process model has an objective centred entry point even though we start by defining the problem and its motivation. From this point, onwards all the steps were followed orderly.

Chapter 3

3. Problem

This step is mapped in DSRM process model as the problem and motivation step. In the first place, we identified and atomized the problem as it is described in the section below along with the motivation of the proposed solution. Afterwards, we state the research questions based on the previous problem definition.

3.1. Overview

The present economic context is characterized by constant and fast paced changes that force organizations to look for different ways of satisfying client's expectations. Keeping a competitive advantage and good profit margins, at the same time, requires an outstanding cost control. This cost efficiency requires a constant analysis of business activities to understand the effective return from each product. In short, cost efficiency is a big game changer in terms of competitive advantages of an organization.

The increasing competitiveness of the markets is demanding lower prices, forcing companies to work on lower profit margins. In addition, *"the financial and economic crisis as SMEs and entrepreneurs have suffered a double shock: a drastic drop in demand for goods and services and a tightening in credit terms, which are severely affecting their cash flows" [10] and, although the general financing situation of companies has improved ten years after the crisis, there are, in 2017, still major financing problems for younger companies [11]*. Therefore, these companies in order to get financing are exposed to strict cost reduction demands that guarantee more robust financial results. This demand for cost efficiency requires a strong cost analysis capacity that organizations very often do not have. In sum, companies have the option of searching for more revenues through higher prices – creating market disadvantage and reducing demand – or reduce costs. Furthermore, present companies cost structures are fundamentally dominated by overhead costs due to complexity and a proliferation of products and customers [12].

As companies learn how to benefit from the technological advances, using automation and computer software, the original "prime costs" of direct materials and direct labour are starting to become the overhead component. This increase in the proportions of overhead costs is distorting product costs since the traditional management accounting systems are not made to allocate overhead costs to products. Although the paradigm has been changing, cost accounting is still a very much used approach. The main issue, addressed by the literature, surrounds the outdated management accounting systems (MAS) that is not able to deliver detailed information consistent with the current paradigm. The accounting system should not be independent nor in conflict with the corporate strategy [13]. Neither should it only focus on providing state demanded reports [14]. Accurate and relevant cost information is critical for the management's decision making processes and most of the times old methodologies give wrong information and feedback since they are still not able to deal with overhead costs. Since these costs nowadays represent a major part of the company's overall costs, being badly allocated has strong repercussions in the company's strategy.

Nowadays several costing methodologies address the overhead cost problem. These methodologies focus on understanding the activities the organization performs, in order to design the flow of cost until the product or service is delivered. This allows the managers to be aware of where and how much money is spent and what is the profitability of each service or product.

One of the first methodologies was Activity-Based Costing (ABC), which was introduced in the 1980s, allowing companies to obtain more accurate costs of their processes, products, and customers. This methodology ended up having a low adoption because of the high cost to estimate and maintain ABC systems for large enterprises. Some companies employed more than a dozen employees to maintain ABC systems. Furthermore, the ABC software took many weeks to collect data and calculate product and customer profits and losses each month [15].

In addition to these ABC's problems some other more methodological problems arose. In the first place this model requires that most of the resource expenses are assigned to the activities based on interviews and surveys, a process, not only expensive and time consuming, but very often inaccurate. As a solution to this problem Kaplan and Anderson proposed Time-Driven ABC that defines a set of equations of time for each activity performed inside the organization thus eliminating the costly and subjective surveys of employee's time allocations. Furthermore, it skips the step of driving resources cost to activities thus eliminating the need to allocate department's costs to the multiple activities it performs [15]

However, even though TDABC solves the biggest problems of ABC, many managers still focus on the cost side of implementing such methodology instead of looking to the benefits it can bring to the organization. This mentality leads to the precipitated and generalized conclusion that the benefits do not exceed the substantial cost of implementing and maintaining TDABC [2]. Furthermore, in 2003 surveys on the subject registered a 50% usage of ABC [16] but in 2015 ABC was out of use and some TDABC principles were only used, by 22% as part of organizational time management [17].

Therefore, we can summarize the main problem of our research as:

Problem: *low adoption of TDABC.*

To solve this problem, we propose the use of process cost templates and framework guidelines to implement TDABC on an organization by the means of a cost analysis service [4]. This will allow us to reduce the time of making a proper TDABC cost analysis thus reducing its cost of implementation.

3.2. Motivation

We intend, in this section, as described in the DSRM [5][6], to show the audience the value of solving the previously mentioned problem in order to convince them to pursue it and accept the obtained results.

As we stated in the previous section, the market globalization is increasing the competitiveness for cheaper products thus forcing companies to be more cost aware. Although cost analysis is a “must have” for companies, the implementation process of costing methodologies and the tools used to implement them are seen as expensive [2]. In some cases, as we addressed before, they are not even fit for the new cost paradigm, providing wrong information and leading to wrong decisions.

As it was discussed in the previous section, with the change in the economic environment and the proliferation of products and customer’s companies, cost structure has been changing thus making the old management accounting systems obsolete. This led to the rise of new cost methodologies, more suitable to deal with a general increase of overhead costs. One of those methodologies, and the one our research focuses on, is TDABC which, although it is an optimized version of ABC with lower processing costs, increased system flexibility, improved accuracy, and enhanced simplicity [18], for a lot of managers still is not an investment worth the outcomes [2].

If we look to small-to-medium size enterprises (SME’s) this investment can turn into a barrier leading to an even lower adoption of cost analysis tools. This particular type of companies lack the financial and human resources of the bigger companies. Furthermore, they have smaller infrastructures at a manufacturing, distribution, IT and support level than their bigger competitors. In general, the whole structure and concept of SME is defined by having a small economy of scale that cannot compete in open ground, from a cost standpoint, with bigger enterprises. For that matter, cost awareness is even more important since it enables these smaller companies to achieve maximum efficiency and competitive prices [2].

As it was abovementioned, cost awareness allows us to understand the flow of money inside the organization until the final product or service is delivered. So for organizations it is of major importance

to understand which of the cost objects is being profitable or not, in order to take the correct measures and strategic decisions to gain competitive advantage [19]. Besides wanting to know if a certain product is profitable or not, it is also useful to understand the composition of the price of a product. The total cost is composed by different activity costs which use certain resources. This decomposition is of extreme importance for surgical measures that the manager could put in place. Furthermore, the managers can analyse the used capacity of resources and evaluate their performance, which means knowing exactly how much of that resource is used compared to the full capacity.

For an organization's strategic committee, it is also important to know if the information presented is fully correct so that the policies applied do not have a negative impact. The TDABC method allows to obtain more accurate costs of the customers, processes and products, even compared to its predecessor ABC [15].

In short, what motivated this research was the necessity to increase the adoption of TDABC. The way we decided to do that was by developing a framework based process cost templates that, in combination with an affordable, user friendly and easy to implement application would make cost analysis and cost awareness less time consuming and therefore more affordable. This will help companies to be more efficient and more competitive in the global market.

3.2.1. Motivational Demonstration

In order to better understand the context and to be able address properly the real problems during a TDABC implementation we performed a TDABC cost analysis in a small organization. The organization in question, which we can't disclose the name, organizes workshops on a given matter. Since we intended to analyse the profitability of each workshop student we needed to understand the processes involved in the organization, its costs and its revenues.

Due to the fact that this was a small organization the number of activities involved and their complexity was small. However, small organizations present an extra challenge in the sense that most of the times they don't have their processes defined. The cost awareness is reduced compared to bigger organizations and therefore they need more time spent in field visits, meetings and interviews to understand the resources involved, their capacity cost rate (CCR), the time equations of the activities and, finally, to get input for the time equation's variables.

In order to perform a TDABC cost analysis, we started by gathering the resources and their CCR's – in this particular case the used capacity was 100% for all resources since resources are only hired or bought when they are needed - as they are presented in the following table. As we can see from figure 2, on the right we have all the resources and on the left the activities to which they are allocated.

With this information gathered we focused on defining the 5 activities that comprised part of this organization's work. However, since the activity responsible for the cost of running the workshop accounted for 92% of the costs, we are going to give it more attention.

Resource	CCR
Ads	4,8€/day
Meetup Membership	15 €/year
Photographer	1200/year €
Content Writer	30€/post
Bootcamp Manager	65,8€/day
Professors	183,9€/day

Table 1 - Table of resources for the motivational demonstration

In order to run the workshop only the professors, the manager and the space were needed, however, since the space was free of charge only the first two presented as costs for the organization. The workshop manager had a fixed income every month and the professors received for every day they actually worked which meant the days the workshop was running during the year plus the promotional workshops performed to attract future students. Therefore, after the cost analysis was fully ran, we assessed that the organization's costs circled around 169 962 € and that the revenue obtained from the workshop's tuitions circled 367 360€ which translates into approximately 54% of profit.

During this demonstration, we got a point of view that allowed us to perceive the problem in a different way. For this simple demonstration two weeks of work were required and we realized the factor that led to major delays was the difficulty in understanding how activities were performed and organized inside the organization since nothing was streamlined. As an example, we took two meetings to understand how the costs with a PR agency and Facebook ads costs could be translated into time equations since the first one was used only once and the organization didn't know if they were going to use it again and the Facebook ads activity was performed in an unpredictable way which made our job of defining a time equation difficult. Therefore, this spontaneous and less streamlined definition of processes, very common in small organizations but still real in bigger ones motivated us to find a proposal that might help both the streamlining of processes but also to perform the TDABC cost analysis.

Figure 2 – Resource allocation to each activity

3.3. Research Questions

As it was mentioned in previous sections, with the change in the economic environment and the proliferation of products and customer's companies, cost structure has been changing thus making the old management accounting systems and costing methodologies obsolete. And, even though TDABC is an optimized version of ABC with lower processing costs, increased system flexibility, improved accuracy, and enhanced simplicity [18], for a lot of managers it still is not an investment worth the outcomes [2]. With this being said, it is clear that there should be a less time consuming and resource demanding approach to implementing TDABC. Therefore, in cooperation with a cost analysis service, of a process cost template that facilitates the implementation of a TDABC cost analysis of that same process. We believe this will accelerate the process of cost analysis since there is a higher starting point that might reduce the need for meetings and field visits. Considering all this, we defined the following research question as the basis of our work:

RQ 1: *Can framework based process cost templates help reduce the time and, consequently, the cost of implementation? How?*

In sum, since we want to facilitate the adoption of TDABC, this research question can be answered by developing a framework based artefact that defines a set of resources and time equations for a given process therefore facilitating the future implementation of TDABC. Furthermore we can define that the main objective of this research is to present a framework based process cost template that, on the one hand, works as an accelerator and resource reducer for TDABC implementation but also gives organizations and the departments a cost awareness of their processes and resources [15].

Besides this main objective, this template wants to take other objectives into consideration:

1. The template should be adaptable to different organizations.
2. The template must be expressed so that it can be used and understood by people with different backgrounds.

Chapter 4

4. Related Work

This step is mapped in DSRM process model as the second step and consists on defining the objectives of a solution. We are going to define the goals of our solution based on the previously defined problem and the related work. The related work is going to provide the concepts, methods and available guidelines that are going to help us reach the best solution.

4.1. Cost Concepts

In this sub-section, we define the most relevant concepts of cost accounting necessary to understand the state of the art and the proposal of our research.

Expense – Is a cost that is charged on top of the revenue. It is important to distinguish the difference between an expense and a cost. A cost occurs when we sacrifice resources, regardless if they represent an asset or an expense [20].

Cost – Cost represents a sacrifice of resource incurred by the company. For example, a company that produces airplanes uses some resources, the cost of materials (like sheet metal), costs of labour, costs of using certain machines etc. There are several attributes on which a cost can be classified; degree of traceability (direct when it can be conveniently traced back to a cost back and indirect on the opposite situation); nature (if it is an overhead cost, a material or labour cost); Change in Activity or Volume (fixed if It remains unchanged irrespective of volume of production (e.g. factory rent, insurance), variable (directly associates with unit, increasing and decreasing with production) and semi-variable (portion of these costs remains fixed and the balance portion is variable, depending on their use e.g. electricity bill) [20] [21][22].

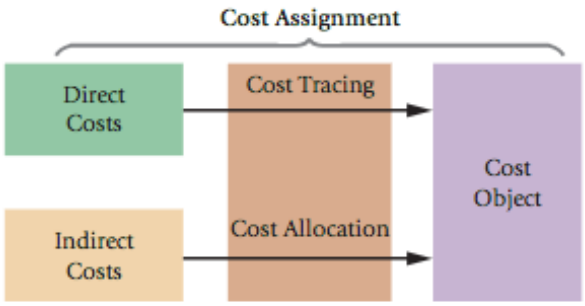


Figure 3 - The general concept of cost assignment

Cost Object – A cost object is any end to which a cost is assigned. Or, in other words, a cost object is something for which a measurement of costs is desired. It includes products, groups of products services, projects, and departments. It can also apply to customers or vendors, among many other possibilities. Cost objects are extremely important in decision making and performance measurement. [20][21][22].

Cost Pool – It represents a group to which several costs are assigned and that group its afterwards assigned to the cost objects. There are some cases where departments can be cost pools depending on the intention of the cost analysis. For example, in a situation where we want to analyse the cost of a department it would be represented as the cost object [20][21][22].

Cost Driver – Cost driver is a variable, such as the level of activity or volume, that causally affects costs over a given time span. The awareness of the cost drivers is of tremendous importance for organization that want to be cost efficient [20][21][22].

Direct Cost of Cost Object – costs that are related to a particular cost object and can be traced to it in an economically feasible way. Any material cost is a direct cost since it can be easily traced to the product or service it is related with [21].

Indirect Cost of Cost Object - costs that are related to the particular cost object but cannot be traced to it in an economically feasible way. Any cost that is not directly related to production is an indirect cost. Some indirect costs maybe overhead costs [21].

Cost Assignment – is the general term that encompasses tracing direct costs to a cost object and allocating indirect costs to a cost object. The first one is called cost tracing and the second one cost allocation like it is presented in the figure 2 [21][22].

Cost Allocation Rule - cost allocation rule is the method or process used to assign the costs from the cost pool to the cost objects.

Product Costs – are costs that result from the production of a product such as direct labour, manufacturing overhead or direct materials.

Period Costs – are costs incurred to manage the firm or selling the product on a given period. These costs are not dependent on the production of a given product and are not attached to products since the company does not need to wait for the sale of products to recognize them as expense.

4.2. Costing Methodologies

4.2.1. Traditional Costing Methodologies

Traditional costing methodologies, like job costing and process costing, separate costs in product costs and period costs. Although, we know how these costs are allocated to production under both job and process costing methodologies they are considered, by some managers, as conceptually flawed. The main reason for these critics is the fact that the finished product should include not only the cost of direct materials, but also a portion of the administrative cost that correspond to the activities that help achieving the final product [23]. In short, in the present economic environment where organizations cost structures are being dominated by overhead costs, the traditional costing methodologies deliver distorted information about the profitability of their products by focusing particularly in the cost of direct labour and materials [12]. As Kaplan stated in his book, *"While manufacturing companies could generally trace the labour and materials used by their individual products, their cost systems allocated the indirect and support costs - the "overhead" – with measures already being recorded, such as direct labour hours and direct labour dollars.*" [24].

4.2.2. Activity Based Costing

Activity based costing is a solution, proposed in the 80's, that attempts to overcome the serious deficiencies in traditional costing methods by seemingly solving the incorrect allocations of overhead costs (e.g. Management, Marketing, R&D) of these methodologies. This requires tracing the indirect and support costs to the activities performed by the company's resources and afterwards assigning those activity costs down to the cost objects (e.g. customers, products) based on the resources consumed by each activity. In other words, it means stopping the conceptual separation between product and period costs, and seeking to find a more correct way to link activities, costs, and products [23] [24].

In activity based costing it is important to define some fundamental concepts. An activity is basically an action or an aggregation of actions that is provided of some cost rate since it consumes company's resources. A resource is taken as an economic element that a certain activity consumes (e.g. supplies).

To implement ABC, it is needed, in the first place, that the consultants identify the organization's own activities. This is achieved by surveying the managers of the departments and in some cases observing how that department works. Afterwards, the identification of cost drivers (activity

consumption cost driver and resource consumption cost driver) and their volume for each activity must be found. Usually this process is also done through surveying using variables like percentage, headcount or any other unit that is found relevant to the cost analysis. In the third place the cost driver rates should be computed, which entails determining the cost of each cost driver unit. The costs are then assigned using ABC. First, based on interviews a cost flow diagram is developed, which assigns costs to activity pools and in a second-stage allocates activity costs to products/services noting the cost drivers for each activity. In the end total costs are calculated by summing the costs of all the activities needed to create the product or service [24][20].

As it was mentioned above, ABC solves the problem of the traditional cost methodologies - allocating overhead costs to products/services based on raw capacity usage indicators that do not reflect the difference between different products - by defining an *activity dictionary* with different activity cost rates that can be used to compose the final cost of different products based on their production and development process.

Although, despite its attractive value proposition, ABC has some pitfalls that led to a low acceptance rate. According to a survey realized in 2003 ABC registered a 50% adoption rate [16] and more recently, in 2015, it was not even contemplated in the survey [17]. This results are surprising in the sense that this methodology gave, otherwise unavailable, insights on cost and profitability of products/services, processes and customers. The main reasons that sustained this resistance in ABC adoption are: The price and complexity to sustain it and modify it. Questionable accuracy of cost allocations since the activity consumption cost driver is estimated subjectively. Despite the vast number of activities, the model was not granular enough to capture the complexity of the operation's processes (e.g. a company might what to make cost of the activity vary based on some variables like distance or type of product). Searching for more detail and granularity about activities requires a big activity dictionary with a nonlinear escalation. In some situations, this results exceeded the capacity of normal spreadsheets tools and took many days to process monthly data. Due to the problems with scalability at an enterprise wide level, models started being implemented in individual facilities and departments which reduced the linkage between different parts of the organization and prevented the managers from having a holistic view of the costs and profitability [24].

4.2.3. Time-Driven Activity Based Costing

In order to solve ABC's pitfalls and try to raise the percentage of adoption by the community, a new approach, called Time-Driven Activity Based Costing (TDABC) was created. It proposes to be more simple, cheaper and more powerful while, at the same time, maintains the ABC basic concept that allowed many companies to identify a profit enhancement opportunities [25].

TDABC replaces all the costly, time consuming and unprecise activity interviews from the previous methodology for the estimation of only two parameters, the capacity cost rate of the resource and the capacity usage in each transaction of that resource. The capacity cost rate (CCR) is the total cost

related to a particular resource (e.g. Marketing) divided by its capacity (e.g. time). So, in this example the total cost of the marketing department would be divided by the time employees spend being productive for the company. Using these two parameters and multiplying them results in the total cost spent by an activity. In conclusion the TDABC model simplifies the implementation and the whole costing process by not requiring interviews to allocate resource costs to activities [24].

Secondly, this new methodology incorporates the variability in time demands made by different transactions. It allows much more granularity in the sense that it is able to capture much more variations and complexity than the previous model. Furthermore, it does not demand excessive storage and processing power. To achieve this granularity the methodology uses time equations.

Organizations can, most of the times, predict the drivers that make activities more simple or complex. By knowing those drivers and having a flow chart of how the activities are performed it is possible to create a time equation that predicts the time taken to perform it. Let's take for example the department of distribution of a health products company that packages the products for shipment. A normal sized health product may take one minute. Although, if that item requires special protection package it will take three more minutes and if it is being shipped by sea one more minute to place it in the container. So basically, while ABC would require to define one activity for every combination TDABC estimates the demand with one equation:

$$\text{Packaging time} = 1 + 3 * \{If\ it\ requires\ special\ protection\} + 1\ * \{if\ shipped\ by\ sea\}$$

Furthermore, TDABC is able of providing more information than just profitability and cost structure of an organization, it can also give information on resource performance which is done by comparing the capacity of a certain resource and the respective used capacity. There are situations where some unused or excessive capacity exists meaning that the resource is not being fully used or, in the second case, being overused. This analysis helps the management team making resources more efficient thus helping even more cost efficiency.

4.3. Time-Driven Activity Based Costing Implementations Guidelines

In this sub-section, we are going to approach the general implementation guideline that helps to organize a project to implement Time-Driven Activity Based Costing. According to Kaplan, the TDABC implementation should be divided in four phases, preparation, analysis, pilot model and rollout.

Phase 1 – Preparation:

Firstly, a team with the correct experience and expertise should be put together in order to successfully implement the TDABC model. In the first place, the active participation of a senior

management (Executive Sponsor) is of extreme importance in order to help sustain the project since a project like these encompasses all the organization's units and departments. Secondly, IT personnel (System Support) on the team are fundamental in order to provide access to data and implement automated data feeds into the model. Finally, the operational personnel are responsible for building the model, the equations and validate the model. Their team leader should be someone with ABC, consulting or project management experience so that he is able to define the model's structure, managing schedule and budget while leading the team internal and external relationships [24].

Secondly, at the beginning of the project, an executive sponsor and steering committee must specify what are the objectives of implementing the TDABC model thus influencing the choice of the project champion. The purposes of a TDABC model can be diverse, process improvement activities, analytic basis for charging the cost for the IT department, Human resources and other support departments, facilitate the stock-keeping unit rationalization process and, finally, increasing the profitability by allowing the transformation of unprofitable customers into profitable ones [24]. The project champion should be, as it was abovementioned, chose based on the specific objectives. A project that aims to measure the customer profitability should have the head of marketing or sales as the project champion. Although, if the project aims to identify ways to implement process improvements and cost reductions the vice president of manufacturing or operations would be the best choice [24].

Finally, this phase is also responsible for determining the boundaries of the implementation of the model. The first implementation should be a pilot study with a limited scope of the whole company (e.g. one facility or department) in order to reveal, quickly and without the risk and high cost, the benefits and implementation cost of the model. With the specified boundaries of the implementations, and based on the pilot study that should have always bared in mind the future migration to an enterprise wide context, the team should specify deadlines, budgets, and the sources for the data that needs to be collected [24].

Phase 2 – Data Analysis:

The model requires access to detailed transactions and orders data so that it is able to achieve a good level of accuracy. Furthermore, there should exist extensive data fields in the ERP that allow the TDABC to capture the specific characteristics of each transaction. Otherwise the model will not be able to show the different resource consumptions by different orders, customers or units.

During phase two, the team, with help of the finance and IT departments, extracts the general ledger and transactions files from the ERP. In case the project is still at a pilot level, the assignment of staff department costs, like HR and IT, can be left out of the scope and then more accurately incorporated when the model is scaled. Once all the departments costs have been captured they can be decomposed further if there are multiple processes in a department in a very straightforward way.

Afterwards, within each department the estimation of the time equations is conducted by the project team which conducts interviews or direct observation to two or three members to understand the key

processes, the activity steps, the drivers that cause the variation in the capacity and the average time by step [24]. In order to develop time equations, creating the process maps for each activity of the organization is fundamental.

Process maps encompass the steps that each activity goes through in an organization thus they should include all relevant resources required for each activity step. In general literature, process maps or more simply chronological lists of the process steps are the most used methods. The most common data collection method for mapping processes are contextual observations although interviews are often used in conjunction with observations. In conclusion, the best option is to develop a preliminary process with staff interviews and workshops and then complement and confirm with observational data [26] [27].

Phase 3 – Building the pilot model:

In this phase the project team uses the previously developed time equations to make the linkage between the department costs to the cost objects (e.g. customers, units). To do this the team learns the following steps, that will, in the future, be generalized for the whole organization [24]:

1. Link the general ledger to department costs
2. Link department costs to one or more processes
3. Load all transaction data from the organization
4. Insert the time estimates obtained from the time equations for each process
5. Obtain the process costs via time equations and resources CCR.
6. Calculate cost and profitability for the cost objects

This pilot model is of extreme importance to learn how to automate data feeds from the ERP into the TDABC software. This step prepares a future escalation to an enterprise wide model by preparing the team and assuring that the model can do what it is intended to do. In general, it develops experience and expertise on a small-scale model so that the escalation of the TDABC model to the whole company (encompassing hundreds of thousands of transactions) becomes simpler and with less risks.

After the model is built and running, the team needs to validate its results in a financial and operational way. The financial validation consists in making sure that the costs assigned in the model reconcile with all the data on the general ledger. The operational validation evaluates the accuracy of time equation. This is done by comparing the total departmental times recorded by the model in each activity with the available time estimated by the number of employees and machines in that department. After this comparison, the team needs to give special attention to large amounts of overused and underused capacity by asking if there was any mistake in resource or activity allocation on those activities. Only after this verification is done can the model be trusted by the stakeholders.

Phase 4 – Enterprise wide launch:

In homogeneous companies, the model rollout is much easier, since this step mainly consists in escalating the work done in the pilot study. The model structure implemented at the pilot site serves as template for all other facilities since the processes, departments and time equations for activities are very similar. Although, in more heterogeneous companies the pilot study team behaves like a consulting group for the enterprise wide launch that helps training other project teams in each of the organization facilities.

4.4. Costing Templates

In this sub-section, we are going to talk about costing templates for companies inside the same industry. These are a way of accelerating the implementation of a costing methodology.

Business Processes and Cost Templates

Business process templates are a mechanism to reduce costs of implementing a given cost methodology through reutilization and standardization of business processes for organizations in the same industry. As it was described in the literature, *"a method, that models an industry's business processes and costs, and creates a template than can be later instantiated to organizations belonging to that same industry"* [28].

The above-mentioned method was developed as a composition of two phases, the Modelling phase and the Application phase. The first phase is a one-time development procedure where the field or industry is analysed and where a generic cost model is developed using an organization in that same field/industry. The second phase of the methodology is responsible for implementing the previously developed template in a specific organization. The model instantiation consists in applying real costs to the model, removing or adding activities that might be in excess or missing and even changing some if necessary in order to reflect the specificities of that particular organization. These adjustments are necessary since all companies, however similar they are in that industry, have different structure particularities and different costs that need to be embedded in the model [28].

The Modelling phase is composed by the following six major steps that allow the modelling of an industry costing template [28][29]:

1. **Cost Object Hierarchy** – This step will indicate in which cost objects the results will reflect and how they can be organized to help structuring the analysis. This is done by creating a tree that represents the multiple levels of aggregation of the cost objects, starting at the individual transaction level and then moving up creating groups according to where the analysis should be focused.

2. **Identification of Resources** – After defining the cost object hierarchy all the resources should be gathered and organized in resource pools (set of resources that work together for some role). This structure of resources makes it easier to identify direct costs, and create ways to allocate the overhead costs to functional departments.
3. **Definition of Activities** – After identifying all the resources and structuring them, the executed activities must be identified. For each identified activity, the usage of resources should be assessed. In order to associate the activities with resources and their costs, BPMN and TDABC's time-equations are used. Furthermore, each activity is linked through a time-equation with only one resource pool.
4. **Construction of Business Processes** – Given that the value proposition of this methodology relies on maximizing reutilization, a way to achieve that is to use the same activity in different processes. The business processes are, in short, a composition of different activities with a given order. Therefore, to obtain process costs the ones that resulted from the time-equations defined for each activity composing that same process should be summed.
5. **Allocation Processes to Products** – Costing the cost objects (e.g. services/products) is done by summing all the costs of the processes that contribute to that cost object.
6. **Definition of Segmentation Products** – In this step are defined, in the template, some common levels of variation since inside some industry there is sometimes some segmentation that can be based on a number of variables.

The generic industry cost template that results from this phase is then used in the application phase and applied in the organization. This phase is composed by the following five steps [28]:

1. **Resource Cost Gathering** – The model defined in the previous phase defines the resources of the organization and how costs are allocated to support and functional resource pools. Although, in order to apply the template to a specific organization, it is necessary to gather the total cost of each resource and the practical capacity for each of the functional resource pools (in order to calculate the CCRs).
2. **Segmentation Variables Choice** – In this step the segment of the template is chosen based on the variations that better match the organization.
3. **Application of template** – Instantiating the model means replacing all the variables (the cost of resource pools, the practical capacity of each resource pool and the CCRs calculated with these values) defined in it by the actual values of the organization.
4. **Adjustment of template** – Since organizations usually have particularities that differentiate them from other companies in the same industry, adjustments to adapt the template for a particular organization should be done. These adjustments include actions like adding, removing and adapt activities or changing variables in the time equations.

5. **Calculation of costs** – The cost calculation is done by applying the TDABC methodology. The model receives the input data from transactions and applies that data to the time equation variables in order to calculate costs.

In a final stage, although not considered as an independent step, there is a control component which aims to give a continuous attention to improving the quality of the template. In this phase the manager's feedback on the generic model is of great importance. All in all, this method takes advantage of the concept of business process standardization in the sense that the more organizations standardize their processes the more accurate the model will be. It can help organizations, particularly the small ones, by facilitating the standardization of their processes, without obviously losing their particularities, allowing, at the same time, a reduction in the cost of implementation [28].

This proposal is not completely able to solve the identified problem since it is still difficult, costly and time consuming to apply the modelling methodology in organizations of bigger size when a basis (e.g. framework) to work from is not being used. This requires analysing completely the companies processes right from the beginning through observation and interviews instead of using them just to fill in the blanks.

4.5. CMMI

In this sub-section, we are going to explore CMMI since it is a solid framework that is going provide us important information for the development of our proposal. Its activities and best practices are going to be the baseline for the development of our proposal.

CMMI (Capacity Maturity Model Integration) models are a set of best practices designed to help organizations streamline process maturity and encourage more productive and efficient practices in software, service and product development. It was developed by the Software Engineering Institute at Carnegie Mellon together with the US Government as a tool for process improvement. All in all, CMMI is based on the principle that every service or product is the reflex of its process of development and offers guidelines for process improvement.

CMMI is composed by three different products: CMMI for development which focuses on the best practices for product and service development; CMMI for services which focuses on service establishment, management and delivery; CMMI for Acquisition which focuses on the best practices for acquiring product and services.

Since the first release in 2002 CMMI has already seen different releases (v1.2, v1.3 and v2.0) although that last release was v2.0 in this research we are going to use the version 1.3 since the 2.0 version was released while this research work was already up and running.

Therefore, based on what was abovementioned and since our research will focus on the development of an IT Service, our research is going to make use of CMMI for Development v1.3. CMMI for development "*consists of best practices that address development activities applied to products and services. It addresses practices that cover the product's lifecycle from conception through delivery and maintenance. The emphasis is on the work necessary to build and maintain the total product*." [30]. It contains twenty-two process areas, from which sixteen of those process areas are common to all CMMI Models, one is just shared by two CMMI Models and the other five are development exclusive process areas. These development process areas address the following practices: development of requirements, technical solution, product integration, verification, and validation. Therefore, due to the level of detail related to product and service development this framework is going to be used as basis for our proposal.

4.6. COBIT 5

In this sub-section, we are going to explore COBIT5, also a framework that is going to be used during the development of our proposal. Together with CMMI it will provide insight for the development of the proposal.

COBIT5 is last version of the COBIT framework for guidance on enterprise governance and management of IT developed by ISACA. It stands on fifteen years of practical knowledge and application by many enterprises and users from business, IT, risk, security and assurance communities. COBIT5 provides a set of guidelines and best practices to help enterprises create optimal value from IT by maintaining a balance between realising benefits and optimising risk levels and resource use. Furthermore, it allows IT governance to have a holistic view to the entire organization. COBIT 5 is generic and useful for organizations of all sizes, whether they are public or private [31].

COBIT 5 is built around for core principles: meeting stakeholder needs, cover the enterprise end-to-end, applying a single, integrated framework, enabling a holistic approach, separating governance from management [31]. These principles are the basis to create an effective framework that potentiates the IT investment and use for the benefit of stakeholders.

COBIT5 includes several products. However, the one in which we are going to focus is *COBIT5:Enabling Processes* [32]. *COBIT5: Enabling Processes* is a reference guide to all the processes defined in the COBIT process reference model. In sum, it defines and details (e.g. activities, responsibility chart) a set of IT management and IT governance processes that companies should implement in order to achieve optimal results for the stakeholders. This set is composed by thirty-seven processes, divided between governance and management, that should be implemented according to the organizational and stakeholders needs. Finally, this framework is going to be used in order to demonstrate our proposal in an organization.

4.7. Costing Tools

In this sub-section, we are going to explore the context of costing tools in TDABC implementation.

Even though costing software is essential to perform cost analysis, the costs associated to a software like this prevents many organizations, especially SMEs, from thinking of it as an option. Although this is still a reality, according to recent reports, by the end of 2018 the majority of organizations will have a migration plan in place to shift their spending from perpetual software licensees to subscription-based pricing [33]. This change in the paradigm allows companies to see a software as an operational expense instead of a capital one making it more attractive, especially for SMEs.

A costing methodology like TDABC can be very difficult and time consuming to implement, fortunately there is software that facilitates the implementation. This kind of software has been developed to ease the data capture, results processing, implementation methodology, and analysis functions for most of the mainstream costing tools. Usually they are integrated with source transaction systems and are able to export results to business intelligence software [34].

The most common tools used for TDABC implementation - Acorn Systems, SAP PCM, SAS ABM, Oracle Hyperion PCM, Cognos, QPR CostPerform, etc. – are perpetual license products that require a big investment. As it was abovementioned, this investment can be a barrier to many organizations thus opening space in the market for Software as a Service (SaaS).

Based on that market loophole, our research is going to use a cloud-based costing service developed by digital costing [35]. This tool allows organizations to reduce their costs by offering costing as a service instead of an investment, allows the full application of the TDABC methodology by receiving an imported input of data from the ERP and provides to the managers a set of reports about the capacity of the resources and the profitability of the cost objects.

Chapter 5

5. Proposal

This step is mapped in DSRM process model as the design and development step and focus particularly on creating an artefact. This artefact is a proposal for a practical solution to the problem previously identified.

As it was mentioned in previous sections the fact that, for many managers, the benefits do not exceed the substantial cost of implementing and maintaining TDABC plus the fact that it represents a big capital investment for organizations, are the main problems preventing the adoption of TDABC. Therefore, our proposal aims to reduce the factors of cost increase such as time required for implementation, expertise and expensive software.

Based on this context, we propose the use of **process cost templates and framework guidelines to implement TDABC on an organization through a cloud-based costing tool.** In reality, in order to reduce the scope of the research, our proposal consists on developing a cost template for the process of IT Services Development using CMMI and COBIT5 as references. We decided to choose this process since, according to the insight we got from experts, it stands out from the researches already performed in the field by being a less standardized process across organizations. This will allow us to challenge the concept of cost template and understand more about how it works in different contexts. Moreover, it is of our belief that this proposal will reduce the expertise and time of implementation needed to execute the methodologies mentioned in the related work, as it was previously proposed by Jorge Emanuel et.al [29]. Furthermore, we have noticed from the previous work that conclusions were difficult to reach due to the use of a very standardized business process that limited the assessment of how cost templates could be implemented in more complex processes that may suffer much more differences from organization to organization.

In sum, the use of process cost templates consists in defining, *a priori* - using the appropriate frameworks together with interviews and field visits - the process, its activities, the resources that maybe involved and, finally, the time variables that influence those activities. The way we see it, this previously defined cost template will accelerate the implementation of TDABC in organizations by

reducing the need to observe the processes in field, by reducing the number of meetings with staff and by reducing the number of experts and expertise needed to implement such costing methodology. Taking as an example the motivational demonstration described in chapter 3 if we had a cost template for how to manage bootcamps it would be possible to adapt it to that context in fewer meetings and field visits. A cost template supports the communication by giving both a process overview and displaying a similar cost structure.

In this research, we developed a cost template for the process of IT Services Development strongly focused on the activities that take part on the actual Software Development, which justified our choice of CMMI as fundamental framework. With this cost template, we intend to provide organizations with a tool that enhances cost awareness – which leads to a more accurate pricing - when it comes to the developed software, both internally and externally. Furthermore, we used COBIT5 to help us assess the labour resources associated with each activity. The use of both these frameworks, together with interviews to experts in the field, gave us the ability to create a cost template with a good level of detail that is still able to provide organizations with the flexibility to adapt it to their own environment.

5.1. Framework usage and boundaries

As it was abovementioned this cost template makes use of both CMMI framework and COBIT5 framework. Since in this research we decided to limit the scope to the process of IT Service Development, which consists on all the practices starting in the planning of a product or service until its final execution and verification, the use of both these frameworks was also limited to fit that scope, meaning not all the literature provided by both the frameworks was used in this research.

The use of CMMI was comprised to the document of CMMI-DEV v1.3 since this document focuses on providing a set of best practices regarding the activities involved in the development of products and services [30]. Furthermore, It addresses practices through all the product's lifecycle from conception through delivery, highlighting all that is needed to build and maintain the total product [30].

The use of COBIT5 was comprised to *COBIT5:Enabling Processes* [32] in order to obtain the governance and management responsibilities associated with each of the CMMI processes. The mapping of the CMMI and COBIT5 was done through the ISACA's COBIT5/CMMI practices pathway tool [36].

The CMMI-DEV document is composed by 22 process areas, from these, only 5 are categorised as Engineering processes (Product Integration, Requirements Development, Technical Solution, Validation and Verification). Being these last processes more directly linked to the software development as a process we decided they should be the laying ground of our cost template. Therefore, and after discussing this matter with experts in the field, we gathered the fundamental practices within each of these processes and assembled them in a more practical and simple order

that could be more easily implemented by organizations and could fit the need of a costing context instead of a process improvement one.

Having clarified the use and boundaries of both CMMI and COBIT5 we proceed to present and explain the developed cost template.

5.2. Process Cost Template

To create an IT Service Development cost template, we started not only by analysing the CMMI-DEV v1.3 - in particular, the five engineering processes (Product Integration, Requirements Development, Technical Solution, Validation and Verification) - and *COBIT5: Enabling Processes* but also the particular field we were working in, as proposed by Lourenço et. al [28]. The analysis and creation process was always followed by IT specialists which gave us the needed validation and feedback. Furthermore, after analysing and understanding how the template process should be organized in terms of activities we needed to analyse with a practitioner and academic the relevant cost variables and the main resources involved.

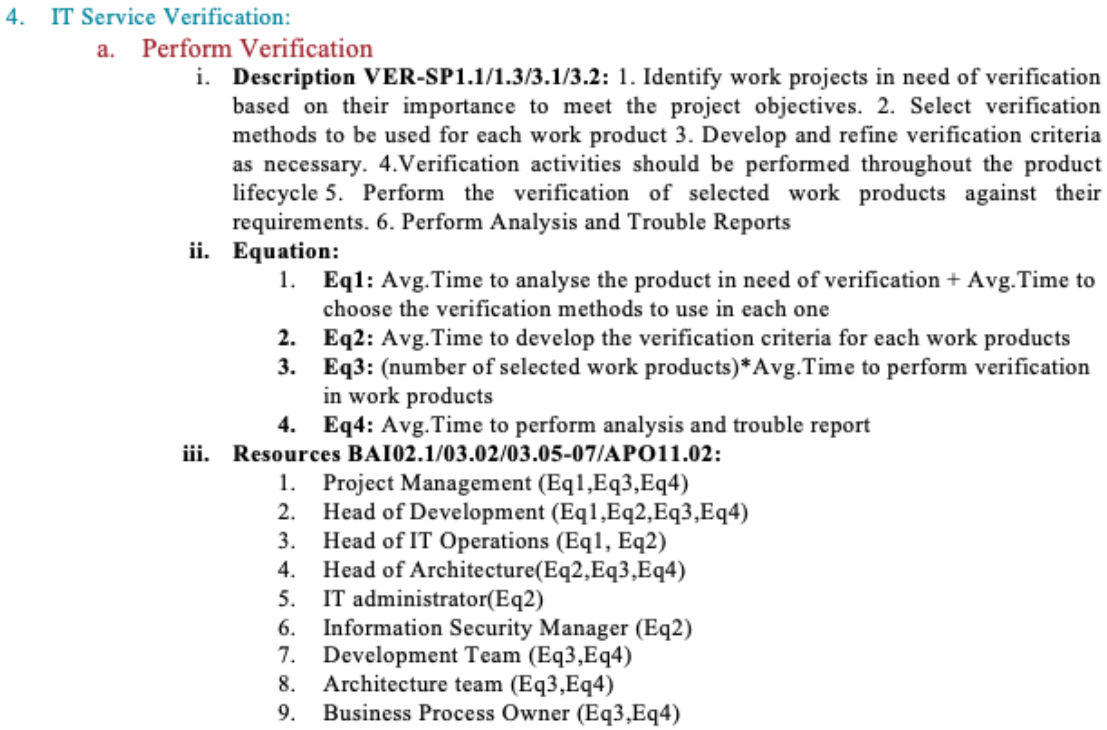
In order to follow the logical process of development we will start by showing a general view of the template and its four main activities. Afterwards, we will proceed to detail each sub-activity that composes each of the main activities. The main activities that compose our cost template are:

1. **IT Service Requirements –** This activity's major responsibility is to assemble the requirements of the service in development, refine them and establish functionalities and quality attributes. Therefore, it starts by assembling the stakeholders needs and transforming them into customer requirements. Afterwards, the technical requirements should be extrapolated from the previously defined requirements. Thirdly the activity focuses on identifying external and internal interfaces plus their requirements. Finally, scenarios and operational concepts are defined in order to refine requirements and defining functionalities and quality attributes.
2. **IT Service Design –** This activity focuses on defining the possible solutions, choosing the right solution, design it. Therefore, it starts by selection the right solution for the problem and the product components that are going to compose it. Afterwards, the capabilities and structure of each of those product components is defined. Finally, the team decides how should those product components be acquired (Make, buy or reuse).
3. **IT Service Implementation –** This activity is responsible for the implementation of the previously developed design and for developing all the necessary support documentation.
4. **IT Service Verification –** The phase of verifications occurs along the development of the product; it is responsible for verifying the product against the requirements and the customer.

In all its extension, this IT Service Development cost template is comprised by 4 activities (or processes) and 13 sub-activities. To represent those, we decided not follow the same BPMN notation proposed by Lourenço et. al [28] so that, as it was discussed with different experts, it could be more easily understood by the non-engineer staff and therefore meet one of the previously defined

objectives. As it can be seen by the following picture, which represents the used notation for just one of the sub-activities, the time equations and the respective resources used by each one of them represent the needed variables to calculate the cost of each of the sub-activities using TDABC.

Furthermore, each of the sub activities – identified with the CMMI and COBIT5 processes they map with - has a description intended to provide context on that given activity and, in some cases, some best practices and procedures for that context. This feature provides the cost template the ability of redirecting the user for further process optimizations.



4. IT Service Verification:
   a. Perform Verification
      i. **Description VER-SP1.1/1.3/3.1/3.2:** 1. Identify work projects in need of verification based on their importance to meet the project objectives. 2. Select verification methods to be used for each work product 3. Develop and refine verification criteria as necessary. 4.Verification activities should be performed throughout the product lifecycle 5. Perform the verification of selected work products against their requirements. 6. Perform Analysis and Trouble Reports
      ii. **Equation:**
         1. **Eq1:** Avg.Time to analyse the product in need of verification + Avg.Time to choose the verification methods to use in each one
         2. **Eq2:** Avg.Time to develop the verification criteria for each work products
         3. **Eq3:** (number of selected work products)*Avg.Time to perform verification in work products
         4. **Eq4:** Avg.Time to perform analysis and trouble report
      iii. **Resources BAI02.1/03.02/03.05-07/APO11.02:**
         1. Project Management (Eq1,Eq3,Eq4)
         2. Head of Development (Eq1,Eq2,Eq3,Eq4)
         3. Head of IT Operations (Eq1, Eq2)
         4. Head of Architecture(Eq2,Eq3,Eq4)
         5. IT administrator(Eq2)
         6. Information Security Manager (Eq2)
         7. Development Team (Eq3,Eq4)
         8. Architecture team (Eq3,Eq4)
         9. Business Process Owner (Eq3,Eq4)

Figure 4 - IT Service Verification sub-activity from the cost template

In reality, as we can see on the image above, we divided each of the sub-activities the following way: firstly, description and best practices - mostly based on CMMI recommendations but also on feedback - secondly their time equations and, finally, the resources involved in each time equation. We will start describing the cost template, presented in Appendix A, activity by activity and presenting the main decisions that lead to its final form.

5.2.1. IT Service Requirements

The first activity of the cost template - subdivided in six sub-activities - represents the phase of development on which the team is responsible to gather the requirements that represent the

stakeholder's needs [30]. These requirements may consist in constrains related to a particular design solution, attributes the product should present or even needs that should be taken into account in various product lifecycles. All in all, there are three types of requirements gathered by the team in this activity: product requirements, customer requirements and product components [30]. These requirements are gathered in the following sub-activities:

5.2.1.1. Assess and Transform Stakeholder's Needs, Expectations and Constraints Into Customer Requirements

This sub-activity is divided into two steps, the first one focuses in gathering needs from the stakeholders and the second one consists in creating the requirements with the previously assessed needs. These two steps were the ones translated into two time equations since they are the basis of this sub-activity. In the first equation, regarding the gather of needs, three variables were accounted for: The first one and the hardest to calculate being the average time by stakeholder (consists in the time spent in methods for eliciting needs like interviews, questionnaires and surveys). The second and third ones being the number of stakeholders and number of revaluations on the lifecycle. In this sub-activity, we decided to account for the average time per stakeholder since companies are not in a state of awareness and time control that allows them to know the precise time per stakeholder, as it was assessed in different organizations.

Regarding the resources involved in this phase, and presented in appendix A, they are the result of our crosscheck analysis between what COBIT5 proposes and what was discussed with different experts. Moreover, because this sub-activity's cost is mainly related to labour overhead costs it is only logical that the important involved resources are of that same type.

During this whole cost template, the direct costs related to the development of the service are left aside since they may vary from company to company and from project to project therefore being difficult do template. On the other hand, many indirect costs like miscellaneous supplies, being impossible to template, depend on the ability of the organization to trace them to projects otherwise they are widely allocated to the department.

5.2.1.2. Establish and Maintain Product and Product Component Requirements

This sub-activity focuses in developing technical requirements derived from the previously defined customer requirements that are usually expressed in customer terms without any technical description. Therefore, it is comprised of only one time equation with the particularity of having an if condition and five variables. The if condition assesses if the customer requirement represents a design

decision and, if so, accounts for the average time the team takes to derive the technical design requirements. As the demonstration of the following section will show, this time is measured through the number of meetings performed on that matter plus a practical analysis of the time the team took on this problem. Furthermore, the equation's permanent variables assess the time to put customer requirements in technical terms and the time to develop the architectural requirements that capture the necessary quality attributes and their measures.

Resources wise, this sub-activity involves the architecture team, development team and IT administration. The first two, plus the supervision of the project management office, are responsible for developing and maintaining the technical requirements together with the IT administration that is responsible for establishing the quality requirements and measure.

5.2.1.3. Identify Interface Requirements

The sub-activity responsible for identification of Interface Requirements consists in assessing both internal and external product interfaces and their respective requirements. Therefore, this sub-activity time is calculated through one time equation that depends on the average time the team takes to identify interfaces and the average time to identify requirements for each of the interfaces. Although the Interfaces are identified and defined at this stage the future technical solution processes might lead to changes in the service architecture, as the design evolves.

In terms of resources, under the supervision of the project management team, the architecture team, the Development and Operations teams are responsible for this sub-activity. Even though throughout the template there is a clear separation between Development team and Operations team through the meetings with the experts and with the experience we had in an IT department it became clear that although many organizations join both Development and Operations teams the cost template should keep the separation to maintain its flexibility.

5.2.1.4. Develop Operational Concepts and Scenarios

This sub-activity consists in defining scenarios - a sequence of events that may occur in the use, development or sustainment of the service – used to expose functional and quality attributes. Moreover, it is also responsible for defining the operational concepts which, together with scenarios, help define the interaction of the product and product components with the user, environment etc.

The time equations comprise two phases, the first one focusing on developing the scenarios and operational concepts and a second one responsible for reviewing and updating the requirements based on the scenarios and operational concepts. The first equation has an if condition for when alternative solutions still weren't developed requiring the development of conceptual solutions to analyse the initial operational concepts.

Since the development of scenarios and operational concepts is an iterative process the requirements updates, contemplated in the second-time equation, should be held periodically. Regarding the used resources, this sub-activity is performed by the Development and Architecture team, under the supervision of the project management team that is usually responsible for refining and updating the requirements.

5.2.1.5. Establish Functionalities and Quality Attributes

This sub-activity is responsible for performing the functional analysis – in order to establish the required quality attributes and functionalities - and describing what the service is intended to do. It may include inputs, outputs, actions or information about its usage. This functional analysis is usually performed using scenarios walkthroughs with the stakeholders. Therefore, the only time equation depends on the variable of average time spent with the stakeholder to walkthrough the scenarios and the number of stakeholders on this project.

In terms of resources, again, the responsibility lies on the head of development and architecture with the supervision of the project management office which should always be present in the meetings with the stakeholders.

5.2.1.6. Analyse and Validate Requirements

This sub-activity consists, on the one hand, in analysing the requirements in order to balance the stakeholders needs with the assessed constraints of the project. And, on the other hand, in validating the requirements with users to be sure that the requirements will lead to a successful validation in the end. Therefore, to accomplish this sub-activity models, simulations and prototyping are used both to understand the balance of the needs and constraints and validate the requirements with the stakeholders. Moreover, a risk and cost analysis is performed to the requirements so that there isn't any situation where a strict requirement that could be more loose has, for example, a high impact on cost.

This phase is timed through three time equations, the first of them depends on the time taken to develop the models, simulations and prototypes and the number of those that are built. The other two depend on the time the cost and risk analysis performed by the risk and audit team take. Therefore, the used resources in this phase are the already mentioned risk and audit team plus the Development and operations team that maybe involved in the creation of models as well as in the risk analysis. Furthermore, the project management office and the business executives maybe involved as an authority that needs to be informed during this phase and although their participation might not be very exhaustive it may have a significant cost impact.

5.2.2. IT Service Design

5.2.2.1. Develop Alternative Solutions and Selection Criteria

This sub-activity consists in developing and analysing alternative solutions so that the most suitable solution in terms of cost, risk and performance is found. Therefore, this sub-activity encompasses the definition of the screening criteria to select the alternative solutions that should be considered, the analysis of new technologies that could bring a competitive advantage to the service, identification of off the shelf products that could satisfy the requirements, creation of alternatives and allocation of requirements to them, development of criteria to evaluate each of the alternatives and, finally, selection of product components based on a update of the selection criteria defined in the context of the sub-activity 5.2.1.4. In this last step, the alternative solutions are presented to the stakeholders through scenarios and operational concepts and the selection criteria is updated based on the refinement of the requirements. Afterwards this new selection criteria are used to select the product component solutions.

Therefore, based on the way this sub-activity is performed, we developed seven time equations that reflect the previously defined steps. The first equation measures the time the team takes to identify the screening criteria to select a set of alternatives. The second equation assesses the time the team takes to perform a report in new technologies and off shelf products. The third and fifth equations depend on the number of alternative solutions and the average time to develop and evaluate them, respectively. The forth, sixth and seventh equations analyse the time to develop the selection criteria, update it based on the interaction with the stakeholders and time to identify the product component solutions based on the updated selection criteria. All these equations give the organization the liberty to add variables depending on the way each of these steps is performed as we will see in the demonstration.

5.2.2.2. Develop a Design for the Product and Product Components

This sub-activity is mainly comprised of two steps: *"Preliminary design establishes product capabilities and the product architecture, including architectural styles and patterns, product partitions, product component identifications, system states and modes, major intercomponent interfaces, and external product interfaces."* [30] and the detailed design where the structure and capabilities of the product component are fully defined. The definition of variables that influenced this phase was mainly achieved based on the interviews and field experience. We realised that in phases of actual development the best way to calculate the time was by developing a set of charts for time of development depending on a set of values for each of the previously defined variables.

Therefore, for this phase of development we defined as variables: Type of client (usually based on the organization's experience, e.g clients from different industries), this variable may give the organization an idea of how much working hours the development will need. Type of product, meaning if it is a simple or complex product component according to the organization experience. Precedent, if the product is precedented or unprecedented previous experience can reduce design time. Designers familiarity with design tools, methods and techniques such as prototyping tools, object oriented design, design patterns etc. Using this variables and observation the organization can create a table of time of development knowing for example that a simple product component may only require rapid prototyping techniques thus taking less time and a more complex and unprecedented product component may need a multiyear prototyping. Furthermore, it is added to the development time the average time for criteria and standard verification, documentation of the design and compatibility with the requirements.

In terms of resources, the development of the design is performed by the Development and Operations team together with the IT administration team, supervised by the project management office. However, the requirements compatibility assessment is performed mainly by the Operations team.

5.2.2.3. Design Interfaces Using Criteria

This sub-activity is responsible for defining the interface specification for product components. They usually reflect parameters that should be specified to guaranty a given applicability. This phase should identify interfaces between product components, with external items but also with service related processes. Therefore, the defined time equation for this phase analyses only the average time the development, operations and IT administration team take to identify and select the interfaces.

5.2.2.4. Make, Buy or Reuse Analysis

This sub-activity consists in determining what product components should be developed, acquired or reused. This analysis begins during the iteration of design and is affected by a set of factors defined in the CMMI framework such as functions of the products, available project resources and skills or cost of acquiring versus developing internally. Therefore, the time equation involved analysis the time the CIO, the head of development, head of operations and IT administrator take to make this decision.

5.2.3. IT Service Implementation

5.2.3.1. Implementing the design

This sub-activity - and the most relevant for our demonstration since it was the one with biggest cost impact and our major focus – focuses on the actual coding of the whole defined architecture. Similarly, to the activity responsible for the Design Development, to calculate the time we propose the creation of a set of charts for time of development depending on a set of values for each of the defined

variables. In this sub-activity, the only time equation measures the time spent in the implementation of the design and the accounted variables are:

1. **Complexity** – analyses, based on some criteria defined by the organization, the complexity of the service;
2. **Precedented and Unprecedented work** – if the there is experience in similar implementations.
3. **Type of implementation** - if it is the full stack development of a service or if, for example, it focuses more on the frontend.
4. **Familiarity of the team with the coding language and technology** – a factor that may influence the time the team takes to implement the service;
5. **Number of functional and non-functional requirements** - are both two factors that may indicate a longer implementation time due to, for example, more functions and integrations.

This sub-activity is performed both by the Development and Operations team with supervision of the project manager. In bigger organizations, the intervention of the project manager (or is office) is usually less frequent, in smaller organizations the intervention is more frequent. Recently in agile environments the role of the project manager (also Scrum Master) is much more close to the development team.

5.2.3.2. Develop Support Documentation

This sub-practice develops the documentation that will be used to install, operate, and maintain the product. It is also responsible for reviewing and making sure the issues affecting the operation, installation and maintenance documentation are solved. Therefore, the only time equation defined here analyses through two variables the average time to review the requirements and issues plus the time to develop all the support documentation. This sub-activity is usually performed by the Development and Operations teams.

5.2.4. IT Service Verification

5.2.4.1. Perform Verification

This sub-practice focuses on performing the verification of the product and/or work products with the defined requirements thus guaranteeing that the product meets the customer, product and product component requirements. It defines four time equations. The first one measures the time to select the work products to be verified and the respective methodologies to do it. The second measures the average time to develop a verification criteria for each of the work products. The third equation measures the average time to perform a verification. The last one measures the average time to develop and present the analysis and trouble report.

5.3. Cost Template Implementation

The template implementations must start with understanding which resources are going to be used. This means, not only, the resources proposed in the template should be adapted to the particular context but also that the other resources the organization is able to allocate to the project and we aren't able to account in the template (e.g technological costs, Hardware etc.). Afterwards CCR's of each of the resources or their cost should be accounted for and implemented in the costing tool. The last step is to instantiate each of the time equations, after performing the necessary changes, on the costing tool.

However, since the costing service we are using doesn't allow the implementation of time tables for the variables of the activities, the costing of Design development and Implementation needs to be done in an excel spreadsheet and imported to the costing service. The need for this tables is due to the fact that in reality, as we were able to assess, it is very difficult to measure times related to development and implementation continuously.

To run the model, the transactions with the values for each variable on the time equations are given to the software and it will return a costing calculation of the project together with a resource consumption analysis.

Since this model is based on CMMI and COBIT5 it might happen that the organization in question isn't implementing any of these frameworks best practices. However, we believe the simplicity and flexibility of the template not only enables a company with those frameworks implemented to accelerate the implementation of their TDABC cost analysis but also helps companies without any of those best practices to put them in place while implementing a better cost analysis of their projects.

Chapter 6

6. Demonstration

This chapter is mapped in the DSRM process model as the demonstration step where we present the value of our proposal. Therefore, we decided to do it by implementing the proposal in a Banking organization where we gathered information. Moreover, this demonstration intends to show that the previous proposal can be used to solve the problem presented in chapter 2.

In order to demonstrate our proposal, we intended to calculate the cost of a service development at a IT Department using an organization as starting point – in this case a Banking organization. The demonstration consisted in instantiating the cost template in an IT department. However, due to the limitation of manpower and time, we focused most the efforts in detailing the implementation of the design. Even though all the other sub-activities were also instantiated with the help of a few experts in the area, the level of detail was reduced due to the lack of time for more infield observation and access to further privileged information. All in all, the template was instantiated with real values but for privacy reasons is going to be presented with simulated data. After building and implementing the model it was evaluated, as we will see in chapter seven, with experts to guarantee not only that the template could be implemented in different organizations but also to understand its quality in several parameters.

In the demonstration, we will start by explaining the process of adapting the template, collecting the required data and, finally, showing how they were implemented both in the excel model and Costing Service.

6.1. Implementation at a Banking Organization

Our work was performed in a Portuguese private banking organization listed on Lisbon's Stock Exchange. The Banking institution's IT Department on which we performed this field study is an organization with strong process maturity in IT Service Development. In a costing perspective, the

organization implemented a model that allowed the costing of the services developed in house. The cost of all the areas of Development of an IT Service (Management, Functional Analysis, Non-Functional Analysis, Development, Pre-production and Product Support) was extrapolated using percentage from the calculated Development cost. Therefore, our implementation proposes not only to enhance the accuracy of the calculation of the Development Cost but also the other steps of the process.

6.1.1. Template Adaption

The first step in the cost analysis is to understand the resources involved in the Development of an IT Service. In a costing point of view, the resources involved in all the activities of this process represent both direct and indirect costs. The first being composed by Internal employees, Hardware and infrastructure costs and the second miscellaneous costs and other organization's expenses that can't be mapped directly to the development of IT Services.

The set of internal employees, Hardware and infrastructure involved is composed by project managers, administrators from different areas, DevOps staff, Architecture staff, IT administration staff, risk analysis staff and audit staff. In terms of hardware and infrastructure the cost allocation varies from project to project – since it is out of the scope of our cost template and we can't detail specific information about what hardware and technologies were used we will not give much emphasis to this matter. The second set is composed by a set of costs that we didn't have access but comprises expenses such as electricity, building rent, office material, among others.

After understanding the resources involved in the process we needed to know both the number of each of the resources assigned to that service development and their CCR's. In the following table (Table 2) we listed all this information. In order to understand the CCR of each resource we needed to know the actual cost of each of the resources and its practical capacity. Since none of these values could be disclosed we considered different costs for each resource and, based on the organization, we considered a capacity of eight hours per day and twenty days per month, with a practical capacity of 87,5% based on what we retrieved from the interviews. Therefore, taking the DevOps team as example, the monthly cost is 17600€ and the practical capacity per month is 140 hours which means the whole team CCR is 125,7€ per hour and the CCR of each team member is 12,57€ per hour. After assessing the resources, we can move to analyse the adaptations to the cost template in terms of time equations and understand how the costing of Design implementation sub-activity was modelled.

Resource	CCR (per hour)	Number of units
CIO	89,3 €	1

Project Manager	59,2 €	1
IT administrator	23,8 €	1
IT administration team	50,2 €	4
Head of DevOps	25 €	1
DevOps team	125,7 €	10
Head of Architecture	25 €	1
Architecture team	125,7 €	10
Risk Team	50 €	5
Audit Team	50 €	5

Table 2 - Used Resources, their CCR's and number of units

The cost template adaptations were performed after a set of several meetings with experts both from within and out of the organization. Overall, it took us two months to gather all the needed information and finish this model, this time accounted for 7 meetings – two meetings with the organization representatives and five with two experts - with the experts and organization. The cost template adaptation finished with 13 activities, and 40 time equations. Besides the activity of design implementation that is further explained in the following section we are going to detail the example of three of the identified activities.

In the activity, responsible for developing alternative solutions and selection criteria (Figure 4) the first-time equation of the cost template and the forth one were translated into one time equation for both the Project Manager and the Head of DevOps. The first one has as only variable the number of meetings performed for the development of the screening criteria and based on the interviews we considered an average time of two hours plus the time taken to select the set of solutions for consideration based on the criteria. The second equation allocated to the Head of DevOps is basically the previous equation but instead of the time of selection has the time spent developing the screening criteria for solutions and the selection criteria. The second equations of the cost template translate into a simple equation that only allocates the time of creating a report on the available technologies and its allocated to the Heads of the three areas. The third equation is divided in two, the first one is allocated to the whole resources in the DevOps department and has as variables the number of alternative solutions, the average time for the development of an alternative solution and the whole second equation. The second one is composed by that variable that measures the number of meetings the

Project managers has during the development of solutions times the average time the experts estimated to be one hour. The fifth equation presented in the cost template was split in two equations that analyse the time spent in evaluation meeting with the project manager and the actual time spent to evaluate each solution, as seen in the following picture. The sixth equation was passed as the same equation to the Head of DevOps and architecture. The project manager was left out since the meeting with the project manager wouldn't have a big in pact in terms of time in the experts' opinions. Finally, the last equation in the cost template measures, in practice, the time the Head of DevOps and IT administrator take to develop a report on the product component solutions.

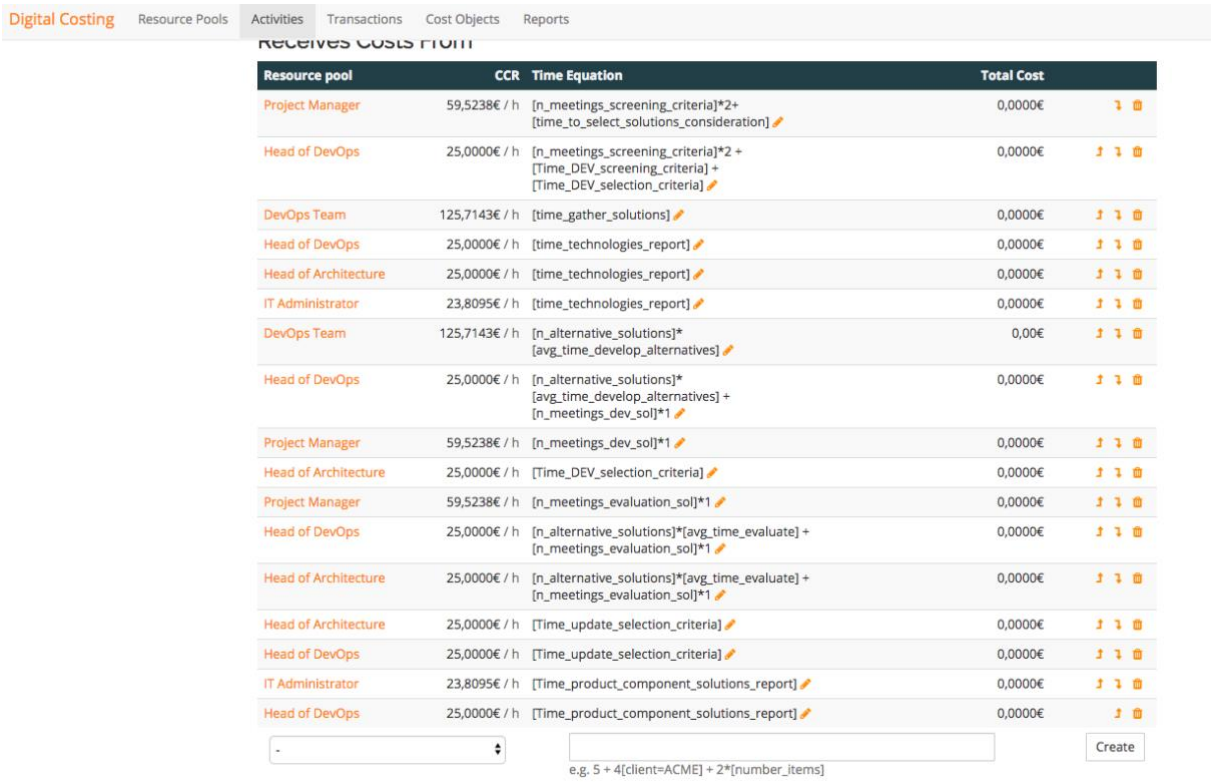


Figure 5 - Time equations involved in the activity of developing alternative solutions and selection criteria

The activity responsible for assessing and transforming the stakeholders' needs into customer requirements kept, like it was presented in the cost template, two time equations. The first equation was allocated to the project manager and the head of DevOps and was composed by three variables that measured the number of re-evaluations during the project lifecycle, the number of stakeholders and finally the time to gather the needs of the stakeholders. The second equation also allocated to the same resources was composed by the number of re-evaluations variable and a variable that measures the time taken to define the customer requirements and prioritize them.

Finally, the activity responsible for performing the verification of the product and the work products was suffered some minor alterations. The first equation in the cost template was kept similar to the cost template with two variables and allocated to the Project Manager and Head of DevOps. The second

equation accounted for the number of selected work products times the average time to develop a verification criteria for each work product. This equation was allocated to the Head of DevOps and Architecture, to the IT administrator and the IT Security Manager. The third equation depends on the number of work products, the average time to perform the verification for each of them plus the number of meetings with the project manager. This equation is allocated to the Head of DevOps and Architecture while the Project Manager has only the time spent in the briefing meeting and the teams. Moreover, the time spent performing the verification without the briefing meetings is allocated to DevOps and Architecture Team. Finally, the forth equation has as variables the time to elaborate an analysis and trouble report and the number of report meetings with the project manager. The DevOps and Architecture allocate only the first variable; the heads of both areas allocate both variables and the Project manager only the last one.

On the following section, we will detail the adaptations and implementation of the activity responsible for the implementation of design which, according to the organization, represented on average 45% of total cost of the project.

6.1.2. Costing Model Implementation

As it was abovementioned, due to time, manpower and even limitations imposed by the organization, our field analysis needed to be limited in terms of scope which reduced the level of detail in other sub-activities. Therefore, the design implementation, being the most relevant step in terms of cost according to the organization, seemed the right choice for further analysis.

Looking at the costing template, we started by defining the variables on which the time measures were going to depend. After analysing with the experts on the IT department we decided to use as variables for our table of times: complexity, precedence of work, type of implementation. The variable of complexity was directly related to the number of requirements of the project. On this variable, the organization provided the information on which they defined the level of complexity based on those requirements both for work with precedence and without precedence. The type of implementations mainly performed by the department consisted in: Online Implementation that consisted on implementing a full application backend and frontend; Interface online that consisted on developing API's for information requests; Batch implementations consisted on changing or creating batch files (Including Job Control); Database that consisted on performing all kinds of database changes; Parameterization that consisted on preforming value parametrizations. Therefore, with field analysis, several interviews and some previously provided information we came up with the following time table (Table 3) that defines the time of implementation depending on the type, the precedent and complexity of the implementation.

Implementation Time (Hours) Codif. / Unit Testing	Without Precedent				With Precedent			
	Very Simple	Simple	Medium	Complex	Very Simple	Simple	Medium	Complex
Online	10,0	25,0	50,0	80,0	4,0	10,0	20,0	40,0
Online Interface	10,0	25,0	50,0	80,0	4,0	10,0	20,0	40,0
Batch	10,0	25,0	50,0	80,0	4,0	10,0	20,0	40,0
Database changes	2,5	6,3	10,0	16,0	2,5	6,3	10,0	20,0
Parametrization	1,3	5,0	10,0	16,0	1,3	5,0	10,0	20,0

Table 3 - Table of implementation times

Having the times gathered and the CCR of each of the involved resources we moved to calculate the cost of the design implementation sub-activity. The project we are costing, adapted from the real project, consisted in four types of implementations without precedent and of high complexity. The following table presents the time spent in implementation by the DevOps team and the respectivecost.

Item	Type	Quant.	Precedence (U/P)	Complex.	Estimated Time (h)	Adjust. (h)	Adjust. Description	Total (h)
E-commerce website	OL	1	N	C	80,0	15,0	Delay	95,0
E-commerce website API	IO	1	N	C	80,0	15,0	Delay	95,0
Database creation for products/members etc.	TB	1	N	C	16,0	3,0	Delay	19,0
Upload of parameters	PR	1	N	C	16,0	3,0	Delay	19,0
				Total Time	192,0	36,0		**228,0**
							Total Cost	**28 659,6€**

Table 4 - Table of cost analysis for the design implementation

However, the time and cost spent in management actions by the project manager and the Head of DevOps still needs to be accounted for. Therefore, based on our observation the time equations that defined the time spent by both those resources was the number of implementation meetings times the average time spent. We were able to assess that the resources involved were: The Project Manager with two meetings a week lasting one hour with the Head of DevOps; the Head of DevOps everyday with the team during thirty minutes. Therefore, the whole cost of the management actions is 1554 euros. In Sum, the cost of the whole design implementation sub-activity is around 30213 euros. After

performing the cost of the design implementation sub-activity and having the model with all the time equations and resources implemented in the costing service the organization was provided with a tool that allowed them to understand with more precision the actual cost of IT service development. Even though we didn't have time to gather the input data for all the remain sub-activities since it would require a much longer research and field work this model provides a much higher starting point for an increased cost awareness in this IT Department.

Chapter 7

7. Evaluation

This section corresponds to the evaluation phase of DSRM that aims to determine if the proposed solution of this research is able to solve the problem mentioned in section three. Since our research was based in DSRM we decided to follow some of the five evaluation methods proposed by the literature [5]. The five design evaluation methods are [5]:

1. **Observational** – Can be performed through case study when the artefact is studied in depth in a business environment or through field study when the artefact is monitored in several projects.
2. **Analytical** – Can be performed through static analysis when the structure of the artefact is analysed for static qualities like complexity. Through architecture analysis when the fit of the artefact in a technical IS architecture is analysed. Through optimization when optimal properties are demonstrated or optimal bounds. Finally, it can be performed through dynamic analysis study the artefact's dynamic qualities like performance.
3. **Experimental** – Can be performed in a controlled experiment meaning its qualities are studied in a controlled environment or in a simulation if it is executed with artificial data.
4. **Testing** – Can be performed with black box testing which consists on testing the interfaces or white box testing that consists in performing coverage test of metrics in the implementation.
5. **Descriptive** – Can be performed through informed argument which consists in building an informed argument for the utility of the artefact or through scenarios that consists in building a scenario that shows the artefact's utility.

Therefore, in order to evaluate our proposed artefact, we used a Field study as observational method, a static analysis as analytical method and an informed argument as descriptive method.

Therefore, the evaluation of this research is going to be done the following way:

1. **Demonstration** will be used to evaluate the cost template based on the feedback obtained.
2. **Close-ended questionnaires** to get feedback about the cost template from experts in the area.
3. Design Research Evaluation Framework [37] using Moody and Shanks Quality Framework [38] and Principles of Österle [39] in order to evaluate the quality of the model and the research.

7.1. Demonstration

The first evaluation step consisted in performing an observational method during the demonstration that took place in a banking organization. This demonstration allowed us to get feedback from the people involved and therefore allowed us to be critic about the perceived benefits of using a cost template.

Our proposed solution for the previously identified problem was to use process cost templates as an accelerator and therefore cost reducer for the implementation of TDABC. Therefore, it was of major importance to understand if the people involved perceived the cost template as a viable solution for the identified problem. This demonstration was performed in a banking organization IT Department with the objective of understanding whether it would facilitate the adoption of TDABC. In order to assess the ability to solve that problem the best approach would be to test the implementation of TDABC with and without costing template in similar environments. Although, since we didn't have that possibility, we decided to implement TDABC using the costing template and gather feedback during and after that demonstration to understand whether the experts perceived it as a valid solution for the problem.

Our demonstration consisted in assessing the cost of a process of service development using our proposal of costing template for that same process. The feedback received in the meetings validated not only the structure and content of the costing template properly but also its ability to be a viable solution for the problem. It was seen as a way of baselining the costing of processes and facilitating the learning curve thus leading to a faster and less intrusive implementation – as we were able to see from the number of meetings and field visits held during the demonstration. Moreover, this work was seen by one of the experts as a proto costing framework. However, some problems were still identified. For instance, in some experts' opinion, the culture of process and cost awareness in a few countries and industries is still not systematized thus making it more difficult in such circumstances for a given process cost template to be implemented.

In terms of the added value to the organization our proposal was seen as a path for a reliable cost information that will support a better decision making. Particularly since we faced and environment where important steps of a Service development weren't detailed. Therefore, building a structure for costing all the steps on the development of service will lead to a better pricing and budget allocation.

Regarding the previously defined objectives of this research it was understood that the template had a clear notation and could be understood even by staff without a technical background. Finally, even though the experts believed that the level of detail applied in the cost template was adequate to allow flexibility for further adaptations to different contexts. They still believed that some differences in cost awareness, process awareness and process maturity might be a barrier to the implementation of the cost template in many organizations.

7.2. Close-ended questionnaires

In order to evaluate our presented proposal, it was important to interview some experts in the area. The preformed interviews lasted around 40 minutes and consisted, firstly, in a brief explanation of the cost template, its organization and structure. Secondly, we conducted a close ended questionnaire that evaluated the developed cost template according to the previously defined objectives of the research. And, in, we got informal feedback from the experts.

In this evaluation, we interviewed three experts: one academic with more than 20 years of experience in Information Systems management and co-author in papers regarding TDABC and cost templates; one practitioner and academic with experience as CIO and Ph.D. on Information Technology Administration; one practitioner with a published paper on costing templates and five years of experience in the industry. For all the interviewees, the cost template structure and notation was clear and understandable. The presented close-ended questionnaire contained eight questions designed to help assess the value of the proposal and how it stands compared to the defined objectives. The asked questions were:

1- Do you Believe Cost Templating of Processes might be a way to reduce the time of implementation of TDABC methodology? (0-10 measure)
2- Do you believe that this proposal of Service Development Cost Template, is an understandable model with a clear notation? (0-10)
3- Is the presented template complete and coherent with what usually are the steps of Service Development? (0-10)
4- Do the Time equation's variables provide the proper level of detail, allowing further adjustments if necessary? (0-10)
5- Do the specified Resources provide the proper level of detail, allowing further adjustments if necessary? (0-10)
6- Does the mapping of processes, equations and resources seem coherent, in your experience? (0-10)

7- Do you believe this template would be adaptable to various organizations (different sizes and different areas of business besides banking)?
8- Do you Believe that this approach will allow organizations to have a more accurate cost estimation of the services developed? (0-10)

7.2.1. Results

In this section, we are going to present a one by one summary of the answers obtained for each of the questions.

1- **Question 1 –** In this first question the average answer from 0-10 was 8. The general feedback received from all the experts was that this template might have the ability to accelerate the implementations of TDABC. One of the experts saw it even as a way to mask the complexity of TDABC in the sense that it systematized the process and the resources and time equations for each activity of the process.
2- **Question 2 –** In the second question there wasn't a consensus in terms of evaluation. The first expert gave it a 4 stating that although the model had a good notation there was still a lack of expertise regarding process awareness and TDABC implementation therefore he believed that this model was still hard to understand since it required a baseline of knowledge in the field. The second expert had a similar opinion of the first but he separated his grade saying that for an expert the notation would be a 9 but for someone not specialized in the field it would be a 5. On the third expert's opinion, the notation was clear and the model was reasonably understandable, representing a 7.
3- **Question 3 –** In this question the answers from the experts were similar and the average was a 6. In the experts' opinion, the template is complete but rather not so coherent with the reality of the present business environment. It was unanimous that nowadays, mainly in Portugal, organizations have a low IT process awareness. Furthermore, it's still uncommon to implement frameworks like CMMI which of course reduces the coherence between the actual process and framework based cost templates.
4- **Question 4 –** In this question the three experts gave 8 out 10. The general opinion was that the presented cost template allowed further specifications thus maintaining the needed flexibility without jeopardizing the required level of detail.
5- **Question 5 –** In this question the average of evaluation was 8 out 10. All in all, the experts agreed that the level of detail of the proposed resources was correct. However, one of the experts recommended that in the future we mapped alternatives for each of the resources in order to facilitate the cost template's adaption.

6- **Question 6 –** In this equation two of the experts answered with an 8 out of 10. However, one of the experts gave it a 3 out of 10 since he considered that the use of COBIT5 only added complexity to the template and destroyed the coherence.

7- **Question 7 –** In this question all the experts had different points of view. One expert gave it a 9 since he believed the template had the potential to be adapted to a vast number of organizations in different sectors and could even be adapted even to small organizations provided a mechanism of simplicity was developed. Another gave it a 4 since, in his opinion, CMMI doesn't adapt well to small organizations. The last one gave it a 7 also stating that depending on the organization this template might need a lot of changes.

8- **Question 8 –** In this last question the experts were unanimous giving an average of 9. All the experts believed that this approach could help organizations to engage on a path to achieve a more accurate cost estimation. However, in the experts' opinion a more detailed accounting of IT and time report needs to exist.

	Question 1	Question 2	Question 3	Question 4	Question 5	Question 6	Question 7	Question 8
Expert 1 (academic)	8	4	6	8	8	3	4	8
Expert 2 (academic and practitioner)	8	5/9[1]	6	8	8	8	9	10
Expert 3 (practitioner)	8	7	6	8	9	8	7	8

Table 5 - Result by question and Expert

7.3. Design Research Evaluation Framework

Evaluation is an important part of the Design Science Research due to the fact that it is responsible for verifying the contribution of the solution for the identified problem and its utility, quality and efficacy [5].

[1] The second expert separated his grade saying that for an expert the notation would be a 9 but for someone not specialized in the field it would be a 5.

In a sense evaluation consists in developing a criteria with which the artefact's performance can be compared thus allowing us to know if the artefact worked [7]. Therefore, we used Design Research Evaluation Framework for choosing the evaluation strategies and methods [37].

This framework identifies what is evaluated, how it is evaluated and when the evaluation takes place and classifies it under two dimensions:

1. **Type of evaluation** – **The Artificial type** of evaluation conducts the evaluation in settings that are not limited to simple experimental settings, but can be imaginary or simulated settings (e.g. simulations, laboratory experiments, mathematical proofs). On the other hand, a **Naturalistic type** of evaluation consists on evaluating the performance of a solution within its real environments.
2. **Time of the evaluation** - The evaluation can be done **ex-ante**, meaning that the evaluation is done before the artefact is developed or **ex-post** meaning the evaluation is done after the artefact was already developed.

Afterwards, by asking the following questions we will be able to classify the artefact on the two abovementioned dimensions:

1. **What is evaluated?**
2. **How is it evaluated?**
3. **When was, it evaluated?**

Our research evaluation, according to this questions answers, will be an ex-post naturalistic evaluation since the process the cost template is going to be evaluated after the development, using interviews to experts and case studies. Furthermore, the framework requires the definition of a process and criteria. In our research, the process is the close-ended questionnaires and interviews to experts, the criteria are the Moody and Shanks Quality Framework and the Principles of Österle.

7.3.1. Moody and Shanks Quality Framework

The Moody and Shanks Quality Framework is a practical and useable proposal to evaluate the quality of data models and choosing between alternative representations of requirements. Furthermore, this framework helps developing commitment to the proposed model by involving all the stakeholders [38]. For that reason, we believe that the following criteria, defined in the Moody and Shanks Quality Framework, is a suitable match to assess our proposal's quality.

Quality Criteria [40]:

Simplicity – Evaluates the size and complexity of the model. In other words, if the model contains the minimum number of entities.

Completeness – Evaluates if the data model is able to meet all the functional and information requirements.

Flexibility – Evaluates the ease with which the model can be adapted to fit different changes of the environment.

Integration – Evaluates how consistent is the data model with the rest of the organization's data.

Understandability – Measures the ease with which the model can be understood by the users.

Implementability – Evaluates the ease with which the model can be implemented according to the time, budget, resources and technology constrains of the project.

Integrity – Evaluates if the model proposed defines all the business rules necessary.

Correctness – Evaluates if the model conforms to the rules of the technique used.

The evaluation results of the application of Moody and Shanks Framework are going to be presented in the benefits dimension of the four principles of Österle evaluation since the multiple dimensions of this evaluation represent the benefits provided by the proposed template.

7.3.2. Principles of Österle

The four principles of Österle for design-oriented information systems research was proposed by ten authors and supported by more than one hundred professors from the German-speaking scientific community. All in all it tries to provide rules for scientific rigor and improved guidance researchers [39]. The four principles are [39]:

Abstraction – Each artefact must be applicable to a class of problems.

Originality – Each artefact must substantially contribute to the advancement of the body of knowledge.

Justification – Each artefact must be justified in a comprehensible manner and must allow for its validation.

Benefit - Each artefact must yield for the respective stakeholder groups.

7.3.3. Results

The evaluation according the four principles of Österle intended to assess the quality of the performed research. In order to present this results we took into consideration all the previously held interviews. Therefore, the evaluation results are:

Abstraction – This template, according to the experts' analysis, has the ability to be applied in the IT Departments of different Organizations provided that the right changes are performed in order to make it fit the particular environment.

Originality – Although proposing process cost templates has a solution was something already done before it was performed in very standardized processes. Therefore, reducing the ability to assess the potential of using cost templates in complex processes. All in all, our research was seen by the experts as an original proposal since it also might be the laying ground for a process cost framework.

Justification – The proposed template is supported by the theoretical concepts defined in the related work, by the demonstration performed and finally the evaluation and feedback gathered during the interviews with the experts.

Benefit:

Simplicity – According to the experts the presented template has the appropriate size and complexity. The number of variables and resources addressed provides the necessary level of detail without jeopardizing the future adjustments that might be needed in order to adapt the template to a different organization.

Completeness – According to what was analysed with the experts the template is complete since it is coherent with the steps performed in an IT service development process and CMMI. However, the coherence with the actual processes performed might decrease significantly in organizations with less process awareness and framework oriented.

Flexibility – According to the experts the template presented a level of flexibility in its resources and time equations conveyed by the ability to adapt the variables and resources to fit the context of different organizations.

Integration – The template is consistent with the organization that's going to implement it since it costs a process of that same organization.

Understandability – According to the experts' feedback even though the model has a clear notation its understandability is still dependent on the user's knowledge on the field.

Implementability – Implementability is dependent on two factors. First, it is dependent on the ability to measure the time for each of the time variables on the time equations (a higher level of granularity will require more information thus requiring more resources). Moreover, it will depend on the difference between the cost template reality and the reality of the organization since a bigger gap between them will also require more resources.

Integrity – Since the template was built on top of CMMI activities and best practices it defines the business rules considered to be more relevant. However, differences in the activities actually performed in a given organization might be found and introduced in the template.

Correctness – According to the experts involved the presented cost template was considered to be in conformity with the general context of IT Service Development. However, as it was previously mentioned, the cost template might diverge more or less from organization to organization, specially in organizations less framework oriented.

Chapter 8

8. Lessons Learned

In this section, we are going to detail the lessons learned through this research lifecycle. Starting in the phase of problem identification and finishing in the artefact's evaluation phase. Most of these lessons were obtained during the experience of performing the work in field.

On the phase of problem identification, we observed, based on the literature, that for the managers the added value of implementing TDABC was not worth the implementation cost. Therefore, we implemented TDABC in a small organization in order to understand the practical problems that surround this cost methodology and dive deeper into the problem. It made us understand that the smaller structure of these organizations and their small economy of scale works as a disadvantage, from a cost point of view, in competing with bigger organizations. Furthermore, in our motivational demonstration we understood that the lack of process awareness and their definition results in a bottleneck for the reduction of time implementing TDABC thus resulting in higher costs.

Regarding the phase of designing the proposal we were able, during the development of the cost template and together with the IT experts, to retain some lessons. The first being that, although following a framework like CMMI might lead to a cost template close to the majority of organizations with strong process awareness, it still lacks the ability of reaching less developed organizational cultures. Furthermore, according to the experts' experience, Portugal is not a country with an organizational culture of process awareness and maturity.

During the phase of demonstration, we were able to retain some important lessons. First of all, we felt some difficulties finding an organization to perform this project. The main reasons were due to the fact that most of the organizations we approached were not either interested in share that type of information or they did not have at that time their processes mapped (in order to implement the cost template without any baseline provided by the organization a whole team would be needed for several months). Secondly, we realized that in order to reach a greater granularity in a TDABC implementation without losing accuracy the organization should have access to a constant stream of time variables.

As we were able to discuss with the experts the only way to achieve this is by acquiring a tool that is able to assess the time for the relevant variables in each of the activities that composes the process.

Finally, during the evaluation step we performed interviews with experts which provided us some insights. First of all, we perceived that the reality is that the majority of the IT firms are not aware of their processes making it more difficult to implement a cost template. Secondly, in the experts' opinion, implementing a project like this at a bigger scale will require a bigger deployment of resources and funds then the organizations are usually interested in spending. However, in their opinion, the paradigm of digital transformation might be an opportunity to implement this level of cost awareness. Finally, we verified that this costing methodology was most of the times unknown even for consultants specialised in costing methodologies, ABC was most of the times referred as the used methodology.

Chapter 9

9. Conclusion

In a global market context where organizations fight for an increasingly demanding customer the ability to provide disruptive but price competitive products is absolutely crucial. However, the ability to deliver competitive prices often comes tied to a strong reduction of profit margins. The struggle for keeping profit margins has prompted organizations to seek for a bigger cost transparency that helps the decision making process in dimensions such as services, products or customers. In sum, costing analysis has the capability of providing managers and decision makers with precise cost insights to support bottom line actions (e.g. price adjusting, reducing product costs).

In order to perform this cost analysis several costing methodologies can be put in place. However, in this research we focus on the low adoption of TDABC. Since ABC was introduced in the 1980's that problems such as its questionable precision in cost estimation and long implementation times are well known. Furthermore, according to a survey performed in 2016 42% of the respondents showed to be dissatisfied with ABC [41]. However, these problems were not enough motivation for managers to see the new version, TDABC, as a costing methodology worth implementing [2]. We intended with this work to propose a solution for facilitating the adoption of TDABC costing methodology by trying to reduce its time of implementation and therefore its cost.

This research was performed through the iterative methodology of DSRM [5] [6] and the guidelines defined by the same methodology. Therefore, we started by defining as fundamental problem of this research the low adoption of TDABC and then proceeded to analyse the present literature and to understand what previously built solutions might serve as laying ground for our work. This led us to propose the use of process cost templates and framework guidelines to implement TDABC. Therefore, and in order to reduce the scope of the research, our proposal consisted in developing a cost template for the process of IT Services Development using CMMI and COBIT5 as reference.

In order to show the results of implementing the previously developed cost template we performed a demonstration in a banking organization by implementing the cost template in the IT department. Due to time and human capital limitations we focused more our implementation on the actual implementation. All in all, through the cost template we gathered the resources involved and adapted the time equations for that given context.

Finally, we evaluated the proposal by using the Design Research Evaluation Framework which led us to define our work as an ex-post naturalistic evaluation with close-ended questionnaire and interviews as process of evaluation and Moody and Shanks Quality Framework and the Principles of Österle as criteria of evaluation.

On the following sections, we will detail the main limitations of this research, its main contributions and finally what future work could be performed in this area so that more knowledge and more solutions are built on top of what was created in this research.

9.1. Limitations

During the research we were able to find some limitations and obstacles mainly to the demonstration of the developed proposal.

Firstly, we found as a limitation to the process of demonstrating our proposal the fact that the cost template was built with the activities and best practices defined in CMMI in mind. Therefore, the number of adaptions on the template would depend on whether the organizations implemented CMMI and at what level of maturity it had the process implemented. This means that on an organization with low cost awareness that does not implement CMMI the implementation of this cost template will still require much time and human capital.

Secondly, our research was limited by the time we had to perform the implementation, the human resources at hand and the difficulty to find organizations to implement the cost template. Therefore, regarding the time and human resources limitation, we were forced to narrow the scope of the proposal and focus more on some parts of the template during implementation. Costing projects are time consuming (especially when processes aren't documented) since the gathering of information depends on field observations, interviews or meetings. Regarding the difficulty to find organizations to perform this demonstration we were limited, on the one hand, by the lack of interest in sharing sensitive information and, on the other hand, by the lack of own process documentation that would make our demonstration too time consuming. Low process awareness would require us to map the internal processes.

9.2. Main Contributions

We believe this research was able to provide to the scientific community some contributions. On the one hand, it provided a solution for the identified problem while, on the other hand, it established the laying ground a future work for, for example, developing a framework for process costing. Moreover, the main contributions were the following.

Firstly, as it was abovementioned, it helps solving the problem of low adoption of TDABC by reducing the time of implementation and therefore its cost. This might be a step to change managers minds since cost was always one of the main concerns for this type of projects. Therefore, we can also say that the developed template works as an accelerator for cost analysis.

Secondly, since the implementation of a costing methodology requires a great knowledge about the processes involved this cost template is able to help mapping processes or even redesigning them according to the CMMI best practices. Finally, it will provide organizations a cost awareness on the developed software that will allow a better decision price making and a more confident organizational strategy.

All in all, we believe this proposal has the potential to leverage the benefits of TDABC by facilitating its implementation. Furthermore, it can be the laying ground for a framework focused on cost process templates.

9.3. Future Work

We believe that this research was able to pave the path to new opportunities in this field. Moreover, due to the previously identified limitations there is still some work that can be done in order to help prove the value of process cost templates in more complex environments provided that both time and human resources are available.

Firstly, we propose that in future work the developed cost template could be implemented in organizations with lower process awareness and maturity. Secondly, for a longer-term work, a cost process template framework could be developed to support organizations on a more extensive implementation. Thirdly, a tool for cost template simplification could be developed in order to facilitate the implementations in organizations with bigger deviations from the template process (e.g. resource structures for different industries, time equation variables for different organization sizes). Finally, this concept can be deepened in order to include different frameworks or even more experiences from other experts.

All in all, most our recommendations for future work consist in optimizing the capacity for wide implementation of the cost templates either by developing new process cost templates, detailing those already developed or even creating tools that facilitate the process of implementation in different contexts.

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Appendixes

Appendix A

IT Service Development Proposal

1. IT Service Requirements:
    a. Assess and transform stakeholder needs, expectations, constraints into customer requirements.
        i. **Description - RD-SP1.1/1.2 (CMMI)**: The needs of stakeholders (e.g., customers, end users, suppliers, builders, testers, manufacturers, logistics support staff) are the basis for determining customer requirements. The stakeholder needs, expectations, constraints, interfaces, operational concepts, and product concepts are analysed, harmonized, refined, and elaborated for translation into a set of customer requirements. Engage relevant stakeholders using methods for eliciting needs, expectations, constraints, risks, and external interfaces. To guarantee that these are clearly identified and understood an iterative process is used during the project. Furthermore, a surrogate for the end user should be used (preferably someone from the team).
        ii. **Equations:**
            1. **Eq1 gather the needs:** Nº of revaluations on the lifecycle*** (**number of stakeholders *(avg.time per stakeholder = interviews + questionnaires (surveys etc.)))
            2. **Eq2 create the req.**: Nº of revaluations on the lifecycle *(Translation into customer requirements + avg.time of prioritizing requirements and define constrains).
        iii. **Resources – APO11.03 (COBIT5):**
            1. Surrogate for the end user (Eq1) – Can be anyone from the team
            2. Business Process Owners (Eq1,Eq2)
            3. Project Management Office (Eq1, Eq2) - Depending on the intervention of the Project Management office. Might not intervene in the requirement creation, only approving and reviewing them (usually depending on the size of the project and the project management team).
            4. Head Architect (Eq1) (and team) (Eq2)
            5. Head Development (Eq1)(and team) (Eq2)
            6. IT Operations (Eq1,Eq2)

    b. Establish and maintain product and product component requirements
        i. **Description - RD-SP2.1:** The customer functional and quality attribute requirements can be expressed in the customer's terms and can be nontechnical descriptions. The product requirements are the expression of these requirements in technical terms that can be used for design decisions. Derive requirements that result from design decisions. Develop architectural requirements capturing critical quality attributes and quality attribute measures necessary for establishing the product architecture and design.
        ii. **Equations:**
            1. **Eq1:** NºCustomer Requirements * (Avg.Time to Develop Requirement in Technical Terms + if(Cust.Req is a design decision) = (Avg.Time to Derive technical requirements from this one)
            2. **Eq2:** Avg.Time Develop Architecture Req.
        iii. **Resources - BAI02.1, APO11.01:**
            1. Business Process Owners (Eq1,Eq2)

2. Project Management Office – In bigger projects the intervention is usually less frequent, in smaller projects the intervention is more frequent. (Eq1,Eq2)
3. Head Architect (and team)(Eq2)
4. Head Development **(**and team)(Eq1)
5. IT Administration team (Eq2)

c. Identify Interface Requirements

i. **Description - RD-SP2.3**: Interfaces between functions (or between objects or other logical entities) are identified. Interfaces can drive the development of alternative solutions described in the Technical Solution process area. 1. Identify interfaces both external to the product and internal to the product (e.g., between functional partitions or objects). 2. Develop the requirements for the identified interfaces. As the design progresses, the product architecture will be altered by technical solution processes, creating new interfaces between product components and components external to the product.

ii. Equations:

1. **Eq.1:** Avg.Time to identify interfaces+ NºIdentified interfaces * (avg.time to define requirements for each interface)

iii. **Resources BAI03.02:**

1. Business Process Owners
2. Project Management Office - In bigger projects the intervention is usually less frequent, in smaller projects the intervention is more frequent.
3. Head Architect (and team)
4. Head Development (and team)
5. Head of IT operations (and team)

d. Develop operational concepts and scenarios.

i. **Description – RD-SP3.1:** 1. Develop operational concepts and scenarios that include operations, installation, development, maintenance, support, and disposal as appropriate (consistent with the level of detail in the stakeholder needs, expectations, and constraints). 2. Define the environment in which the product or product component will operate, including boundaries and constraints. 3.Review operational concepts and scenarios to refine and discover requirements. 4. Develop a detailed operational concept, as products and product components are selected, that defines the interaction of the product, the end user, and the environment, and that satisfies the operational, maintenance, support, and disposal needs.

ii. Equations <u>(this process is held periodically over the project; time of the equations must be multiplied by the number of times the process is held)</u>:

1. **Eq1.** Avg.Time to define operational concepts and scenarios + if(alternative solutions haven been defined) = (Time to develop conceptual solutions)
2. **Eq2.** Avg.Time to review the concepts and scenarios and refine the requirements

iii. Resources BAI02.1:

1. Head Development (and team) (Eq1,Eq2)
2. Head Architect (and team) (Eq1,Eq2)
3. Business Process Owners (Eq1,Eq2)
4. Project Management Office (Eq2)

e. Establish Functionalities and Quality Attributes

i. **Description- RD-SP3.2:** Analyse scenarios through functional analysis to describe what the product is intended to do. include actions, sequence, inputs, outputs, or other information that communicates the way in which the product will be used. The resulting description of functions, logical groupings of functions, and their association with requirements is referred to as a functional architecture. 1. Identify desirable

functionality and quality attributes (Functionality and quality attributes can be identified and defined through an analysis of various scenarios with relevant stakeholders) 2. Analyse and quantify functionality required by end users. 3. Allocate requirements to functions and sub-functions (or other logical entities).

ii. **Equations:**
    1. **Eq1:** nºstakeholders*(avg.time with the stakeholder to define functionalities and quality attributes)

iii. **Resources BAI02.1:**
    1. Business Process Owners
    2. Project Management Office – Someone from the Project Management should be present in this process.
    3. Head Architect
    4. Head Development

f. Analyse and Validate requirements

i. **Description - RD-SP3.4/3.5:** 1. Use proven models, simulations, and prototyping to analyse the balance of stakeholder needs/ constraints and requirement validation. 2. Perform a risk assessment on the requirements and definition of required functionality and quality attributes.3. Assess the impact of the architecturally significant quality attribute requirements on the product and product development costs and risks.

ii. **Equations:**
    1. **Eq1:** nº of models/simulations/proto/demos * (avg.time to develop the model)
    2. **Eq2:** Avg.Time for Risk assessment of requirements
    3. **Eq3.** Avg.Time for Cost assessment of requirements

iii. **Resources BAI02.1,BAI02.3/2.4, BAI03.1:**
    1. Project Management Office (Eq1, Eq2, Eq3) – Intervenes in all the steps but the cost might be ignored depending on the intervention.
    2. Business Process Owners (Eq1,Eq2)
    3. Business Executives (Eq1,Eq2, Eq3)
    4. Head Development (and team) (Eq1, Eq2)
    5. Head of IT operations (and team)(Eq1,Eq2)
    6. Risk Team (Eq2)
    7. Audit team (Eq3)

2. IT Service Design:

a. Develop alternative solutions and selection criteria.

i. **Description – TS-SP1.1/1.2:** 1. Identify screening criteria to select a set of alternative solutions for consideration. 2. Identify technologies currently in use and new product technologies for competitive advantage 3. Identify candidate products that satisfy the requirements. 4. Generate alternatives and allocate requirements for each one of them. 5. Develop criteria to select one of the alternatives (should address design issues for the life of the product, such as provisions for more easily inserting new technologies or the ability to better exploit commercial products.) 6. Selecting product components based on the update of the selection criteria defined in the context of the sub-activity 1 d).

ii. **Equations:**
    1. **Eq1:** Time to develop the screening criteria to select a set of alternative solutions for consideration and select them.
    2. **Eq2:** Avg.Time to build a report in new technologies and off the shelf products
    3. **Eq3:** nº of alternative solutions * (Avg.Time to develop a solution and allocate requirements)
    4. **Eq4:** Avg.Time do develop a selection criteria for the solution alternatives
    5. **Eq5:** Nº of alternative solutions * (Avg.Time to evaluate each alternative with the previously defined criteria)
    6. **Eq6:** Avg.Time do update the selection criteria based on the scenarios and operational concepts.
    7. **Eq7:** Avg.Time to identify product component solutions.

iii. **Resources APO04.4/BAI02.02/03.01:**
   1. Business Executives (Eq1)
   2. Business Process Owners (Eq1,Eq2,Eq3)
   3. Project Management Office(Eq1,Eq3)
   4. IT administrator (and team)(Eq2,Eq7)
   5. Information Security Manager (Eq2)
   6. IT operations(Eq2,Eq7)
   7. Head of Development (and team)(Eq1,Eq2,Eq3,Eq7)
      - Recently companies tend to apply Agile principles thus unifying IT operations, Development and Quality Assurance in one DevOps team.
   8. Head of architecture (and team) (Eq2)
   9. [EQ4/EQ5/EQ6- BP owner, Project management office, head of development, Head of architecture]

b. Develop a design for the product or product component

i. **Description TS-SP2.1:** Consists of two phases: 1-Preliminary: establishes product capabilities and the product architecture, including architectural styles and patterns, product partitions, system states and modes, major inter component interfaces and external product interfaces. 2- Detailed Design: design fully defines the structure and capabilities of the product components. **Practices:** 1. Define a quality criteria to evaluate the design. 2. Identify, develop, or acquire the design methods appropriate for the product. 3. Ensure that the design adheres to design standards and the allocated requirements. 4.Document the design **(**See CMMI TS-SP2.1 for a more detailed set of recommended tasks)

ii. **Equations:**
   1. **Eq1: Time to design the product or product component [It may vary with the following variables]**
      - Type of client
      - Type of product factor (e.g. single product component or complex product)
      - Precendented or unprecedented product
      - Designer familiarity with design method
      - Avg.Time for standard and criteria verif.
      - Avg.Time to document the design
   2. **Eq2:** Avg.Time to check compatibility of the design with the allocated requirements (e.g product components)

iii. **Resources-BAI03.01/BAI03.0/BAI04.3 :**
   1. Head Development (and team) (Eq1)
   2. IT operations (and team)(Eq1,Eq2)
      - Recently companies tend to apply Agile principles thus unifying IT operations, Development and Quality Assurance in one DevOps team.
   3. Project management office (Eq1) - In bigger projects the intervention is usually less frequent, in smaller projects the intervention is more frequent (if interventions are less frequent the cost impact might be ignored)
   4. Head of IT Administration (and team) (Eq1)
   5. Business Process Owners(Eq2)

c. Design Interfaces Using Criteria

i. **Description TS-SP2.3: Practices:** 1. Identify the interface criteria (i.e. critical parameters that should be defined, or at least investigated, to ascertain their applicability) 2. Identify interfaces with other components 3. Identify interfaces with external items 3. Identify interfaces between product components and the product related lifecycle processes.

ii. **Equations:**
   1. **Eq1:** Avg.Time to identify and select the interfaces

iii. **Resources BAI03.02/BAI03.3, :** Head Development (and team), Project management office, IT operations (and team), Head of IT Administration (and team)

d. Perform Make, Buy, or Reuse Analysis

i. **Description TS-SP2.4: Practices:** 1. Define criteria for the reuse of components 2. Analyse if components should be reused, developed or purchased (in the last, take into account the maintenance implications).

ii. **Equation:**

1. **Eq1:** Avg.time to determine which product components should be developed, reused, or purchased.

iii. **Resources-BAI03.04:** CIO, Head Development, Head IT Operations, Head IT Administration, Business Process Owners

3. IT Service Implementation:

a. Implement the Design

i. **Description TS-SP3.1:** Implementation of the design. **Practices**: 1. Use methods of implementation. 2. Adhere to standards and criteria (e.g language standards). 3. Perform unit testing of the components

ii. **Equations:**

1. **Eq1: Time to implement a design and test it [It may vary with the following variables]**
   - Complexity
   - Precendented or unprecedented work
   - Type of implementation
   - Familiarity of the team with the coding language and technologies
   - Nºof functional requirements
   - Nº of non-function requirements (e.g integration between components)

iii. **Resources BAI03.03-05 and 07-08:**

1. Head Development (and team**)**
2. Head of Operations (and team)
3. Project Management Office - In bigger projects the intervention is usually less frequent, in smaller projects the intervention is more frequent. Recently in agile environments the role of the project manager [also Scrum Master] is much more close to the development team.
4. Business Process Owner

b. Develop Support Documentation

i. **Description TS-SP3.2:** This specific practice develops and maintains the documentation that will be used to install, operate, and maintain the product. Practices: 1. Review the requirements, design, product, and test results to ensure that issues affecting the installation, operation, and maintenance documentation are identified and resolved. 2. Develop the installation, operation, and maintenance documentation. P.S- Documentation might be questionable in agile environments due to the constant focus on having a working product.

ii. **Equation:**

1. **Eq1:** Avg.Time to review the requirements and issues +Time to Develop all the support Documentation

iii. **Resources BAI03.5:**

1. Head Development (and team**)**
2. IT operations (and team)
3. Business Process Owners

4. IT Service Verification:

a. Perform Verification

i. **Description VER-SP1.1/1.3/3.1/3.2:** 1. Identify work projects in need of verification based on their importance to meet the project objectives. 2. Select verification methods to be used for each work product 3. Develop and refine verification criteria

as necessary. 4.Verification activities should be performed throughout the product lifecycle 5. Perform the verification of selected work products against their requirements. 6. Perform Analysis and Trouble Reports

ii. **Equation:**

1. **Eq1:** Avg.Time to analyse the product in need of verification + Avg.Time to choose the verification methods to use in each one
2. **Eq2:** Avg.Time to develop the verification criteria for each work products
3. **Eq3:** (number of selected work products)*Avg.Time to perform verification in work products
4. **Eq4:** Avg.Time to perform analysis and trouble report

iii. **Resources BAI02.1/03.02/03.05-07/APO11.02:**

1. Project Management (Eq1,Eq3,Eq4)
2. Head of Development (Eq1,Eq2,Eq3,Eq4)
3. Head of IT Operations (Eq1, Eq2)
4. Head of Architecture(Eq2,Eq3,Eq4)
5. IT administrator(Eq2)
6. Information Security Manager (Eq2)
7. Development Team (Eq3,Eq4)
8. Architecture team (Eq3,Eq4)
9. Business Process Owner (Eq3,Eq4)