

**LEAN PROJECT MANAGEMENT: APPLICATION OF LEAN
PRINCIPLES TO PROJECT MANAGEMENT**

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Abstract

In today's challenging business environments, competitive advantage is of utmost importance for organizations and there is a raising demand for profitable solutions that allow organizations to gain competitive advantage. Two of such profitable solutions are Project Management (PM) and Lean Thinking, recognized methodologies for management and production processes. This dissertation proposes a framework to accelerate the performance of projects through PM practices and lean principles.

To develop the framework, Project Management Officers (PMOs) of renowned Portuguese companies are interviewed. In the first Stage, interviews are conducted aiming to identify key pain points in PM. Resulting from the first set of interviews, lean principles are applied to PM to remedy the identified pain points and develop a Lean Project Management Framework. The interviews identify the most critical knowledge areas in terms of pain points as Human Resources, Scope, and Procurement Management.

In the second stage, experts' feedback is used to validate the developed framework on four pillars: degree of understanding, alignment towards the major pain points, practical applicability, and orientation towards the final result. All the respondents conceded that the newly developed framework considered the major pain points and was oriented towards the final result, projects success. Nevertheless, some respondents considered that up-front lean knowledge is needed and suggested the development of a framework dictionary to improve understanding and practical applicability.

The findings show that the use of traditional lean tools adapted to the PM context can aid in the continuous improvement of processes and practices by conferring role clarity, transparency, and reducing bottlenecks. The Lean Project Management Framework provides a viable approach to overcome the shortcomings of traditional PM practices.

Keywords

Project, project success, lean thinking, project management

JEL Classification

M19 Y40

Resumo

Nos desafiantes ambientes de negócio atuais, a vantagem competitiva é essencial para as organizações, havendo uma constante necessidade de encontrar soluções que permitam às organizações obter vantagem competitiva. A Gestão de Projetos e o pensamento Lean são duas destas soluções, reconhecidas nas vertentes de gestão e de ambiente de produção. Esta dissertação propõe um modelo para alavancar o desempenho dos projetos através de práticas de Gestão de Projetos e princípios Lean.

Para desenvolver o modelo, são entrevistados PMOs (*Project Management Officers*) de empresas portuguesas reconhecidas. Numa primeira fase, as entrevistas visam identificar as principais dificuldades na gestão de projetos. Como resultado destas entrevistas, os princípios lean são aplicados à gestão de projetos para mitigar as dificuldades identificadas e desenvolver um modelo lean de gestão de projetos. As entrevistas identificaram as áreas de conhecimento de Recursos Humanos, Âmbito e Contratação, como as mais críticas em termos de dificuldades.

Na segunda fase, a opinião de peritos é utilizada para validar o modelo em quatro pilares: nível de compreensão, principais dificuldades, aplicação prática e orientação ao resultado final. Todos os entrevistados concordaram que o modelo considera as principais dificuldades de gestão de projetos e tem orientação ao resultado final, o sucesso dos projetos. Contudo, alguns entrevistados consideram necessário haver conhecimentos prévios de princípios lean e sugerem o desenvolvimento de um dicionário para o modelo, para melhorar a sua compreensão e aplicação prática.

Este estudo demonstra que o uso das ferramentas lean tradicionais adaptadas ao contexto de projetos pode auxiliar na melhoria contínua de processos e práticas, conferindo clareza, transparência e reduzindo constrangimentos. O modelo lean de gestão de projetos—*Lean Project Management Framework*—fornece uma abordagem viável para superar as deficiências das práticas tradicionais de gestão de projetos.

Palavras-chave

Projeto, sucesso de projeto, pensamento lean, gestão de projetos

Classificação JEL

M19 Y40

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List of Abbreviations

JIT – Just in Time

PM - Project Management

PMO – Project Management Officer

TPS - Toyota Production System

TQM – Total Quality Management

1 Introduction

The scope of this study is the application of lean principles to project management practices. The work developed matches the guidelines of the fifth edition of the Project Management Body of Knowledge (PMI, 2013).

1.1 Research Problem

In today's times, competitive advantage is an essential aim for organizations (PMI, 2013), as the economic climate provides a continuously changing marketplace, simultaneously raising expectations from customers and challenges to remain profitable for organizations. Firms accordingly seek new management methodologies with the aim of improving their products and services, optimizing their processes, and increasing customers' satisfaction (Tenera & Pinto, 2014). Two of these novel management methodologies in the quest for a competitive edge, are PM and Lean Thinking (Anholon & Sano, 2016; Hines *et al.*, 2004; Jadhav *et al.*, 2014; Womack & Jones, 1996).

In recent years, interest in the concept of PM as a vehicle to implement organizational strategy has been steadily increasing (Pereira, 2012; Mishra *et al.*, 2011). The use of projects and the related PM continues to grow and has developed into a common practice within organizations (PMI, 2013). As suggested by Munns and Bjeirmi (1996), the term project highlights the selection of an activity or task to benefit the company, while PM is oriented towards planning and control. Even though successful projects theoretically contribute to the creation of value and corporate success (Cooke-Davies, 2002), a sizable number of projects are failing in practice and creating significant losses for their organizations (PMI, 2016; PMI, 2015). This can possibly be explained by the challenges of Human Resources (Huemann *et al.*, 2007; Matta and Ashkenas, 2003), Scope and Time Management of projects (Nielsen & Almlie, 2010). Nonetheless, there may be other critical facets affecting project success, the so-called pain points of PM.

One potential avenue to foster project success, is to supplement PM with elements from the adjacent field of Lean (Anholon & Sano, 2016; Tenera & Pinto, 2014). Commonly perceived through its practical and managerial perspective, Lean can support the performance and success rate of projects (Oehmen, 2012), as it leads to increased labour productivity, decreased throughput time and reduced inventory, errors, and injuries (Womack & Jones, 1996). Lean Thinking can be conceptualized as using *“less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering working hours to*

develop a new product in half the time.” (Womack *et al.*, 1990: 256). It achieves this by continuously and consequently identifying and eliminating *muda* (the Japanese word for waste). From a lean perspective, *muda* represents losses that can occur at multiple levels in a program or project and it must be identified and measured at all stages to be subsequently eliminated (Hines & Taylor, 2000; Ohno, 1988). Since its introduction, lean has been one of the most prominent philosophies in the manufacturing industries (Shah & Ward, 2007), but it applies to other contexts as well due to its universal approach (Hines *et al.*, 2004). Over the years, it grew into a strategic approach, and lean principles are now emerging in PM in several industries (Carlborg *et al.*, 2013).

1.2 Motivation

The motivation to carry out the current dissertation arises from personal interest in deepening knowledge about PM. On the other hand, the author considers fundamental the challenge to exercise the concepts acknowledged during an Executive Master in Programs and Projects Management. Consequently, the fact that the author deals with lean principles on a daily basis, awoke the interest in understanding the influence of lean principles on PM practices.

1.3 Objectives

The purpose of this study is to illustrate the application of lean principles to PM. The lean principles, tools and techniques, as well as the different PM processes will be the core of this study. Therefore, the research problem is **the application of lean principles to project management, in order to improve projects performance**. To answer the proposed research problem, it is intended to pursue the following specific objectives:

- Objective 1: Conduct a literature review to gather information about project success, PM, Lean Thinking and lean project management. Starting with an analysis of the principles governing each tool, after which the literature review focuses on researches directly related to the present topic, aiming to identify the so-called state of the art;

- Objective 2: Conduct interviews with PMOs of renowned Portuguese to understand their views on the critical pain points of PM;

- Objective 3: Conduct an analysis of the interviews, identifying the PM knowledge areas with more pain points, followed by the development of a lean project management empirical model;

- Objective 4: Validate the developed model.

The topic will be investigated and comprehended in order to provide managers with a guideline to follow when the purpose is to ensure increased projects success.

1.4 Structure

To achieve these objectives, the next section introduces current conceptualizations of project success, PM and Lean Thinking, whereby particular attention is paid to the different knowledge areas of PM and the principles governing Lean Thinking. Second, the development of the Lean Project Management Framework is outlined. The methodology for the evidence-based research is introduced, after which an overview of the pain points in PM is provided based on the analysed data. The ensuing discussion suggests a Lean Project Management Framework that combines the empirically investigated pain points of PM with suitable lean initiatives and tools. The subsequent section illustrates the framework validation, by presenting the methodology followed by an analysis of the gathered data. Finally, meaningful inferences, limitation and avenues for further research are drawn.

2 Literature Review

In line with the context and the objectives presented in the previous chapter, a literature review about the enunciated topic is required. The aim is to identify the evolution of the scientific thought and consequently of the state of the art, making it possible to outline and to discuss the results of the research on the topic.

The literature review is oriented to four themes: the concept of project success or failure and the challenge to identify critical factors; the concept of PM, its purpose and specificities; the concept of Lean Thinking and its structural foundations translated in its principles, tools and techniques; and the ground-breaking concept of lean project management.

2.1 Project Success

Many factors impact the level of project success. Therefore, it is not a surprise that since the 1960s researchers have been trying to find out what are the critical factors leading to project success. Project success has been dominated by the conventional measures of time, cost, and quality, hence Atkinson (1999) termed these three measures together as the iron triangle. Nevertheless, other researchers defend that in addition to the iron triangle, customer satisfaction (Pinto and Slevin, 1988) and overall satisfaction of stakeholders (Bryde and Brown, 2004) should be also considered. According to Belassi and Tukel (1996) defining the success or failure of a project is a complex decision, that doesn't depend solely on time, budget or predetermined performance criteria. Project success might be seen differently by the different stakeholders, hence a project may be considered successful to the client, but unsuccessful for the end users (Toor and Ogunlana, 2008).

When talking about project success, literature often mentions two components: *project success factors*, which are the elements of the project that may be influenced and consequently influence the project success; and *project success criteria*, which are the elements used to determine the success or failure of a project (Müller & Jugdev, 2012). *Success factors* are in fact amongst the most researched themes over the last years (Padalkar & Gopinath, 2016), showing the relevance of the topic. Additionally, according to Cooke-Davies (2002), something that all projects have in common is the fact that, when successful, they contribute to the creation of value, the measure for corporate success.

However, despite the years of research, the years of individual and collective experience managing projects, the constant evolution of PM professional bodies, and an increase in the use of projects, projects continue to fail and to disappoint stakeholders (PMI, 2016; PMI, 2015; Cooke-Davies, 2002). This fact leads researchers and organizations to recurrently look for new management methodologies with the aim of achieving success (Tenera & Pinto, 2014). Therefore, a literature review on two recognized methodologies to enhance success, PM and Lean Thinking, is performed in the following sections.

2.2 Project Management

Over the past few years interest in the concept of PM as a vehicle to implement organizational strategy has emerged (Pereira, 2012). Currently, organizations rely on PM to succeed and grow (Mishra *et al.*, 2011). Therefore, the necessity to understand the concept and the purpose of PM arises. The following subsections analyse the concept.

2.2.1 Conceptualization of Project and Project Management

The practice of projects and the adherent PM continues to grow and has developed into a common approach within organizations (PMI, 2013). Though PM has existed since the days of the Egyptian pyramids or the Tower of Babel, the Manhattan Project in the 1940s is considered to be the first application of PM as it is known today, with a separation of responsibilities between the project manager and the functional manager. However, the use of PM has only become fashionable since the mid-1990s (Meredith and Mantel Jr, 2011). Nowadays, a vast number of organizations rely on PM to achieve operational excellence and business growth (Mishra *et al.*, 2011).

Due to its evolving nature, there are several definitions of the project construct in extant literature. Munns and Bjeirmi (1996) consider a project to be the achievement of a specific objective, involving a series of activities and tasks which consume resources, while having a definite start and end date. According to the Project Management Institute (PMI, 2013: 3) “*a project is a temporary endeavor undertaken to create a unique product, service, or result*”. Temporary implicates that a project has a definite beginning and end date, while unique means that the product, service or result is different from existing ones. Moreover, Pereira (2012) and IPMA (2006: 13) extend the definition of PMI (2013); according to Pereira (2012), a project is usually a human effort to create change; while IPMA (2006: 13) introduces the terms cost and quality by stating that “*A project is a time*

and cost constrained operation to realize a set of defined deliverables (the scope to fulfil the project's objectives) up to quality standards and requirements.”.

At the same time, Munns and Bjeirmi (1996), define PM as the process of controlling the achievement of the project objectives, through the use of the existing organizational structures and resources, by applying a set of tools and techniques. According to the PMI (2013:5), it is *“the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements.”* Pereira (2012) reinforces this conceptualization by arguing that PM aims to meet the project objectives throughout the five process groups or phases. These five process groups are: initiating, planning, executing, monitoring and controlling, and closing (PMI, 2013). Finally, Meredith and Mantel Jr (2011) insinuate that PM provides an organization with tools to improve the ability to plan, implement and control the ongoing activities.

Although the conceptualizations of the project and PM construct are oriented towards the completion of an endeavour, the term project highlights the selection of an activity or task to benefit the company, while PM is oriented towards planning and control (Munns & Bjeirmi, 1996).

Since the mid-1970s, PM associations around the world have made serious attempts to conduct themselves as professional associations. Considerable time and effort in developing Bodies of Knowledge (BOKs) has been spent (Morris *et al.*, 2006). The PM BOKs are an attempt to map out the knowledge elements of this field, hence some insights are drawn in the following subsection.

2.2.2 Project Management Bodies of Knowledge

For at least six decades, PM has been an established discipline with well-subscribed bodies of practitioners and commonly accepted methodologies and standards (Padalkar and Gopinath, 2016). The named PM Body of Knowledge is the aggregation of knowledge in the profession of PM, including both proven traditional practices, widely applied, and innovative practices, still emerging (Sydow *et al.*, 2004).

Formal PM Bodies of Knowledge have been published in the last decades, such as PMBOK from Project Management Institute, APM BOK from Association for Project Management, P2M from Project Management Association of Japan (Morris *et al.*, 2006) or ICB from International Project Management Association (IPMA, 2006). The PMBOK, APM BOK and P2M are of the most influential publications (Morris *et al.*, 2006).

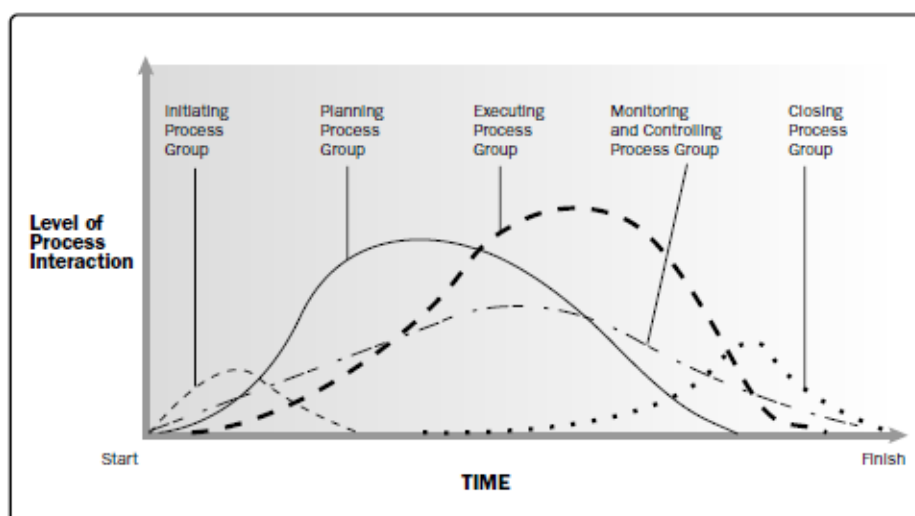
Consequently, the work developed on the present thesis matches the guidelines of the fifth edition of the PMBOK (PMI, 2013). PMBOK provides the globally recognized guidelines for the PM profession, defining PM related concepts, norms, methods, processes, and practices. The guidelines derive from the recognized good practices of PM professionals, which over time have contributed to the development and evolution of the standards, hence it is believed that these guidelines include all the principles of good PM (Anholon & Sano, 2016).

A project may be divided into any number of phases, wherein a phase may emphasize PM processes from a particular PM process group. Some considerations on the topic are presented in the subsequent subsection.

2.2.3 Project Management Processes

In line with PMI (2013), to meet the project requirements an effective management of the PM processes is required. A process is a group of interrelated activities performed to create the desired product, service or result. Each process is defined by its inputs, tools and techniques, and the respective outputs. Consequently, successful PM is achieved through the appropriate application and integration of a total of 47 logically grouped PM processes, which are categorized according to the five process groups. The process groups are linked by the produced outputs and the output of one process usually becomes the input of another process. In case a project is divided into phases, the process groups interact among themselves in each phase and often overlap, as one can see in figure 1.

Figure 1 - Process Groups Interact in a Phase or Project (PMI, 2013: 51)



A brief description of the five process groups required for any project is considered necessary. First, the **initiating** process group, represents the processes linked with the

definition of a new project or a new phase of an existing project by obtaining permission to start. Second, the **planning**, defines the total scope of the project, as well as objectives and actions necessary to achieve the proposed project objectives. Thirdly, the **executing** process group, includes the processes necessary to complete the work previously defined in the PM plan. This process group further includes the coordination of people and resources as well as the management of stakeholder expectations. As for the **monitoring and controlling** process group, it is concerned with the track, review and coordination of the progress and performance of the project. The project performance is measured and analysed in settled time intervals, hence required changes to the project are identified and the respective changes are initiated. Lastly, the **closing** process group consists of those processes performed to formally close all activities from all the previously mentioned process groups. The formal completion of the project or project phase is performed in this process group (PMI, 2013). The five process groups are further organized into ten knowledge areas, as illustrated on Table 1, whereby each area embodies a group of concepts and activities that constitute a PM field (PMI, 2013).

Table 1. Project Management Knowledge Areas Mapping (Adapted from PMI, 2013)

<i>Knowledge Areas</i>	<i>Description</i>
<i>Integration</i>	Ensures that the elements of the project are coordinated and integrated in an appropriate manner.
<i>Scope</i>	Guarantees that the project includes all the necessary work, however nothing beyond the essentials, to complete the project with success.
<i>Time</i>	Secures that the project is completed according to the defined and approved time schedule.
<i>Cost</i>	Assures that the project is completed within the approved budget.
<i>Quality</i>	Pledges that the project will satisfy the needs that justified its initiation.
<i>Human Resources</i>	Aims to optimize the participation of everyone in the project team.
<i>Communications</i>	Warrants that project information is elaborated, distributed and stored in an expedited and appropriate way.
<i>Risk</i>	Identifies, analyzes and defines response plans to the risks that might impact the project.
<i>Procurement</i>	Insures the appropriate acquisition of products or services from outside the project team.
<i>Stakeholder</i>	Highlights stakeholders' satisfaction with the key project objectives.

Additionally, Table 2 depicts the 47 PM processes organized after the five PM process groups and the ten knowledge areas. As one can see on Tables 1 and 2, and in line with PMI (2013), PM incorporates: identifying requirements; addressing the various necessities, concerns, and prospects of the stakeholders; setting up, maintaining, and carrying out communications among key stakeholders; managing stakeholders towards meeting project requirements and creating project deliverables; balancing the competing project constraints, which include, but are not limited to scope, quality, schedule, budget, resources and risks. Therefore, the PM team focus on these factors is of utmost importance, since the projects are dynamic systems that need to be kept in balance and a change in one factor will most likely affect at least one other factor. However, successful project implementation is no longer subject to the traditional “triple constraint”, scope, schedule and budget. Quality, risk and client satisfaction must be also considered (Meredith & Mantel Jr, 2011).

Table 2. PM Knowledge Areas, Process Groups, and Individual Processes (Adapted from PMI, 2013)

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	- 4.3 Direct and Manage Project Work	- 4.4 Monitor and Control Project Work - 4.5 Perform Integrated Change Control	- 4.6 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	
7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
9. Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Control Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Plan Risk Responses		11.5 Control Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.4 Manage Stakeholder Engagement	13.5 Control Stakeholder Engagement	

2.3 Lean Thinking

The lean way of thinking allows companies to specify value, line up value creating actions in the best sequence, conduct these activities without interruption whenever requested, and perform them more effectively. These achievements are conceivable through the use of the six principles of Lean Thinking: value, value stream, flow, pull, perfection and respect for people (Womack & Jones, 1996; Shah & Ward, 2007; Oppenheim *et al.*, 2011). However, there has been some confusion about what lean comprises and what distinguishes this management philosophy. The following sections comprehend a literature review of lean, wherein it is intended to clarify this way of thinking.

2.3.1 Conceptualization of Lean

The term *lean* was used for the first time by Krafcik (1988) in the article “Triumph of the lean production system”, contrasting the traditional belief of the “buffered” production system. Nonetheless, it became trendy only two years later, when it was leveraged by James P. Womack, Daniel T. Jones and Daniel Roos in their book “The Machine That Changed the World” in 1990. Womack *et al.*, (1990: 256) propose that *“lean production... is “lean” because it uses less of everything compared with mass production – half the human effort in the factory, half the manufacturing space, half the investment in tools, half the engineering working hours to develop a new product in half the time. Also, it requires keeping far less than half the inventory on site, results in fewer defects, and produces a greater quality of products.”* Zooming in on the managerial perspective, lean has its roots in the Toyota Production System (TPS) developed by Taiichi Ohno of Toyota Motor Company (Ohno, 1988). TPS focuses on removing any kind of waste and inconsistency in the production system based on two concepts: Just-in-Time (JIT) and Jidoka (Sugimori *et al.*, 1977; Ohno, 1988; Liker, 2004). The JIT method concentrates on producing the right product at the right time, while keeping a minimum level of stock, reducing buffer inventories, decreasing working capital and minimizing time to market (Abdulmalek & Rajgopal, 2007; Tiwari *et al.*, 2011). However, TPS is not just focused on the elimination of waste, but also on the improvement of the product quality through Jidoka. Sugimori *et al.* (1977) refer to Jidoka as a machine with human intelligence, which task is to detect a deviation from a standard and stop, while waiting for help.

Even though lean can be considered a production philosophy rooted in TPS, no common definition exists to date. While Womack *et al.*, (1990) coined the concept and

elucidated manufacturers on how to become lean, Narasimhan *et al.* (2006) insinuated that they failed to provide a specific definition of the lean paradigm. One potential explanation of the lack of clarity and general ambiguity of the term lean could stem from its lengthy evolution and common mistaking with related approaches, such as Six-sigma (Shah & Ward, 2007). Shah and Ward (2007: 786) mention that this vagueness resembles the metaphor of “...*blind men touching different parts of the body of an elephant and imagining very different animals...*”. Thus, the authors implicate that the focus on the components of lean obstructs the understanding of the overall system.

According to Langstrand (2012) lean can have four distinctly different meanings: a condition (being Lean); a process (becoming Lean); a “toolbox” (doing Lean) or a philosophy (Lean Thinking). Generally speaking, the concept mainly exists in production and operation management, but it applies to other contexts as well due to its universal approach (Swank, 2003; Hines *et al.*, 2004; Stentoft Arlbjorn & Vagn Freytag, 2013; Carlborg *et al.*, 2013).

Nevertheless, the meaning of lean has evolved throughout the years, which can be seen on its focus on different inherent principles (Womack & Jones, 1996; Hines *et al.*, 2004). The emphasis has shifted from JIT and cost reduction techniques in the 1980s, to total quality management (TQM) in the early 1990s, to quality, costs and delivery in the late 1990s, and finally to customer value ensuing 2000. The apparent shift from costs to value reveals that lean has evolved into a strategic approach, compared to its operationalization as mere tactics (Carlborg *et al.*, 2013). This transition has enabled the applicability of lean from its traditional concentration to other non-conventional industries and sectors, such as services.

Based on Pettersen (2009), it can be concluded that there is no common definition of lean. Consequently, organizations should not accept any random variant of lean, but make active choices and adapt the concept to fit the organization’s needs. However, it exists a good agreement on the characteristics that define the concept. The following sections make a clarification of the mentioned characteristics, namely principles, tools and techniques.

2.3.2 *The Lean Principles*

Overall the approach of lean can be summarized into six principles (Womack & Jones, 1996; Shah & Ward, 2007; Oppenheim *et al.*, 2011): value; value stream; flow, pull;

perfection; and respect for people. First, lean specifies value; it is defined based on the customer's perspective and includes what the customer is willing to pay for (Abdi *et al.*, 2006). The second lean principle defines the value stream, maps all the specific activities required to deliver a product and highlights areas in which *muda* can be eliminated (Womack & Jones, 1996). The concept of waste, *muda* in Japanese, is defined as any activity that does not add value to the product or project in the customer's perspective (Ohno, 1988). Here fore, especially the viewpoint of the customer is of utmost importance (Abdi *et al.*, 2006). Throughout the analysis of value streams, activities fall into one of the following three categories (Womack & Jones, 1996):

1. Value-Added: Activities that create value and are essential changes to product/service, hence these activities should be maximized;
2. Value-Enabling: Activities that create no value but are unavoidable. Although they might have potential for elimination in the future, they cannot be eliminated immediately;
3. Non-Value-Added: Activities that can usually be eliminated quickly and are not dependent on improvement of other areas. These are redundant activities considered pure waste, thus they should be eliminated.

As part of the third principle, lean creates a continuous flow of work through planned and stream-lined value-adding steps or processes, by eliminating waiting, downtime or scrap time between steps. Successively, the forth principle transforms the manufacturing process into a pull system to respond to customers' demands. Lean minimizes delivering value before the customer requests it and seeks to not provide more than the agreed on initial scope. Fifth, lean pursues perfection through the continuous improvement aim of Kaizen (Liker & Morgan, 2006). According to Womack and Jones (1996), perfection is the complete elimination of *muda*, so that all activities along the value stream create value. Naturally, the pursuit of perfection is an endless process, because the value of all activities can be constantly analysed, evaluated and improved (Abdi *et al.*, 2006). Finally, the sixth principle recognizes that people are the most important asset in an organization and encourages them to identify problems and inefficiencies on a constant basis (Oehmen, 2012).

Succeeding in the previous principles of lean management and thus converting a manufacturing process into lean manufacturing, leads to the following results according to Womack & Jones (1996): double labour productivity; cut throughput time by 90%;

reduce inventory by 90%; cut errors by 50%; and cut injuries. As previously mentioned, this is achievable through the identification and elimination of waste, henceforth a definition of waste is requested.

2.3.3 Waste

From a lean perspective, *waste* represents losses that can occur at multiple levels in a program or project context (Ohno, 1988). As previously outlined, value-enabling activities are required but do not directly create value to the customer, while non-value-adding activities consume resources but do not create any value.

Accordingly, waste must be identified and measured to be subsequently eliminated. As reported by Ohno (1988) and Hines & Taylor (2000), seven different types of *muda* exist: Over Production, producing more than is needed before it is needed; Defects, repair or rework; Motion, any wasted motion due to the lack of direct access to data, people, tools, or systems; Inventory, inventories do not add value, they fix capital and so consume valuable resources; Over Processing, waste inherent to a non-optimized process, where there are non-value added activities or functions; Transportation, wasted effort to transport materials, parts, or finished goods due to installation of processes restrictions; and Waiting, any non-work time waiting for approval, supplies, parts, etc.

The lean approach highlights these different types of waste and provides the tools and approaches to eliminate it. The following subsection introduces lean tools and techniques.

2.3.4 Tools and Techniques

The identification, measurement and elimination of waste can be done by adopting a set of lean tools and techniques. The TPS is the best-known example of lean processes in action and it can be represented as a house, in which individual parts work together to create a whole (Liker & Morgan, 2006), as can be seen on figure 2.

Figure 2 - The Toyota Production System House (Liker and Morgan, 2006)



Furthermore, Table 3 provides an overview of the most readily available lean techniques and tools.

In summary, the different lean principles, tools and techniques aspire to achieve the best quality, the lowest cost, the shortest lead time, the best safety and the highest morale (Womack *et al.*, 1996).

Table 3 - Lean Techniques and Tools

<i>Techniques and Tools</i>	<i>Description</i>	<i>References</i>
5S	Focuses on effective work place organization and standardized work procedures.	Abdulmalek & Rajgopal (2007), Sugimori <i>et al.</i> , (1977) and Womack & Jones (1996)
A3	A visual method for communicating only pertinent information like proposal, problem solving, status reporting and competitive analysis.	Liker & Morgan (2006) and Moreci (2014)
Andon	The use of visual controls, such as overhead displays or electronic dashboards, to briefly convey the status quo of the work.	Liker (2004), Ohno (1988) and Womack & Jones (1996)
Cross-Functional Teams	The aim is to have team members who are able to perform different tasks in order to increase flexibility and reduce variability and risk exposure.	Shah & Ward (2003) and Sugimori <i>et al.</i> , (1977)
Genchi Genbutsu	Encourages workers, team leaders, and executives to go to the <i>Gemba</i> (the place in reality), to inquire a problem directly and work collectively on a solution	Liker & Morgan (2006)
Heijunka	Aims at levelling, because when the work load is levelled, there are opportunities for standardized processes.	Liker (2004), Ohno (1988), Sugimori <i>et al.</i> , (1977) and Womack & Jones (1996)
Hoshin Kanri	A method for ensuring that the strategic goals of a company drive progress and action at every level, aiming to eliminate the waste that comes from inconsistent direction and poor communication	Liker (2004) and Womack & Jones (1996)
Jishuken	A method of gathering managers for problem solving in the production process and continuous improvement	Marksberry <i>et al.</i> (2010)
JIT	Just-In-Time (JIT) concentrates on producing the right product at the right time.	Ohno (1988), Sugimori <i>et al.</i> , (1977), Womack & Jones (1996)
(Daily) Kaizen	An approach for continuous improvement, where Daily <i>Kaizen</i> acts as a daily activity.	Liker (2004), Ohno (1988) and Womack & Jones (1996)
Kamishibai Boards	A visual control for performing internal audits of processes or systems, aiming to train people to understand problems and find possible improvements.	Niederstadt (2013)
Kanban	A way to communicate between processes through a signaling system to help implement a pull system and to achieve a continuous flow.	Abdulmalek & Rajgopal (2007), Sugimori <i>et al.</i> , (1977), Womack & Jones (1996)
Obeya Room	A system that provides dedicated space, as well as time, for coordination and problem-solving, designed to minimize organizational barriers.	Liker & Morgan (2006)

<i>PDCA</i>	PDCA (Plan, Do, Check and Act) is an iterative methodology to propose a change in the process, implement it, measure the results and take appropriate action.	Moen & Norman (2006)
<i>Poka-Yoke</i>	Meaning “mistake-proofing” encourages the use of a range of low-cost, highly reliable devices throughout the different processes to prevent defects.	Liker (2004) and Ohno (1988)
<i>Root cause analysis</i>	An iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem (e.g. 5 Whys, Ishikawa Diagram).	Liker (2004), Ohno (1988) and Womack & Jones (1996)
<i>Standardized Work</i>	Setting a standard and bringing a condition into conformance with that standard, makes it possible for everyone to know what to do and when to do it.	Liker (2004) and Ohno (1988)
<i>Supplier Involvement</i>	A form of vertical collaboration with the suppliers to ensure alignment and accountability throughout the project cycle.	Liker (2004) and Womack & Jones (1996)
<i>Teamwork</i>	Building strong teams facilitates initiatives, which enables more consistent working and the elimination of waste.	Liker (2004), Ohno (1988) and Womack & Jones (1996)
<i>TQM</i>	Total Quality Management (TQM) is a system of continuous improvement that employs participative management techniques centered on the needs of customers. Key components are employee involvement and training, problem-solving teams, statistical methods, long-term goals, and recognition that inefficiencies are produced by the system, not people.	Abdulmalek & Rajgopal (2007) and Shah & Ward (2003)
<i>Value stream mapping</i>	This approach intends to visually map the actual and future state of processes to highlight opportunities for improvement.	Abdulmalek & Rajgopal (2007), Womack & Jones (1996)
<i>Visual Controls</i>	Visual indicators, displays, dashboards or controls used to improve communication of information, by making it easily accessible and clear, to everyone.	Liker (2004) and Ohno (1988)
<i>Yamazumi Chart</i>	The Yamazumi Chart graphically represents tasks or workloads for optimization purposes.	Rahani & Al-Ashraf (2012)

2.4 Lean Project Management

In agreement with PMI (2013), a project is a temporary endeavour designed to create a unique product or service. Nevertheless, when projects aim to deliver the product while maximizing value and minimizing waste, they are considered lean projects. Accordingly, organizations that apply lean principles to their PM practices should be able to identify and weed out processes and activities that introduce wasteful spending. As reported by Gabriel (1997), the lean approach to PM results in project success, meeting quality, time and costs criteria, and leads to a high level of commitment and motivation from the project team and to the satisfaction of the customer.

Similar studies were developed by Anholon and Sano (2016), Oehmen (2012) and Tenera and Pinto (2014), who believed in the merger of lean and PM. Anholon and Sano (2016) assessed lean projects using PM guidelines, while Oehmen (2012) identified the major challenges themes in programs or projects as well as 43 lean enablers to overcome these challenges. The lean enablers are described as actionable best practices structured along the lean principles. Furthermore, Tenera and Pinto (2014) integrated lean, six-sigma and PM.

Commonly perceived through its practical and managerial perspective, Lean Thinking can function as the missing piece in the puzzle, by improving the performance and the success rate of projects (Oehmen, 2012). The amalgamation of lean with PM might be the answer to increase the rate of projects success, yet it requires an extensive examination of all the project activities throughout the entire project life cycle, as well as the lean principles and tools. Consequently, it is of utmost importance to understand how each lean principle can be applied to PM processes, and which synergies exist between them. The task will be undertaken in the following section, resulting in the development of a Lean Project Management Framework.

3 Stage 1 - Lean Project Management Framework Development

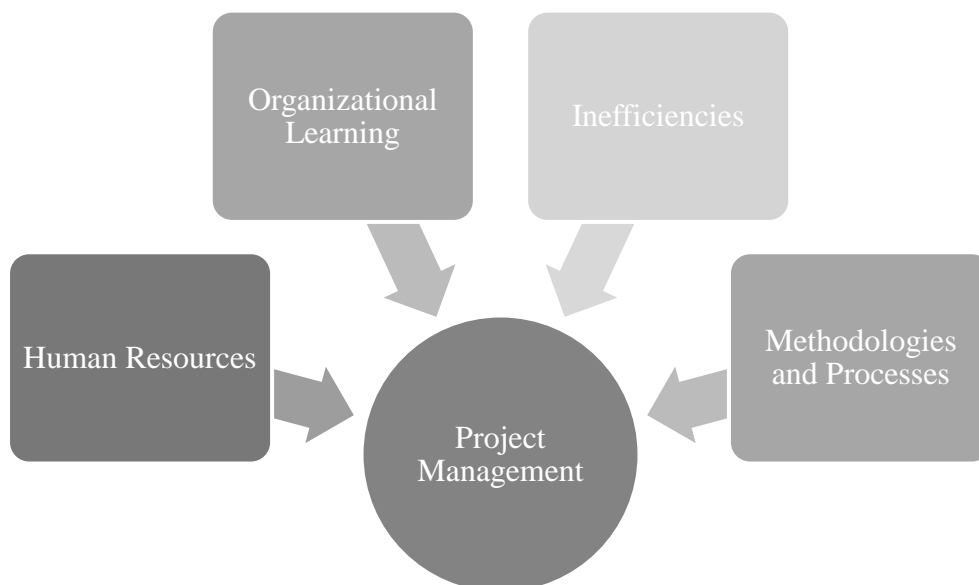
As initially stated, the research problem of the present dissertation is the application of lean principles to PM, in order to improve projects performance. To answer the proposed research problem, interviews with PMOs of renowned Portuguese are conducted; followed by an analysis of the gathered information; and the development of a lean project management empirical model.

3.1 Methodology

This subsection presents and discusses the adopted methodology used to find answers to the proposed research problem. Hence, data collection for the current study was conducted through semi-structured interviews with Project Management Officers (PMOs) of renowned Portuguese companies to understand their views on the critical pain points of PM. Interviews are commonly perceived as a suitable method for data collection to extract in-depth and latent insights that the interviewee might not be consciously aware of (McNamara, 1999).

For the current research, the interviews aimed specifically at discerning the structures of established PM processes and the challenges inherent to them for each of the questioned organizations. Another goal was to inquire the challenges pertaining to each one of the ten PM knowledge areas. Therefore, the interview was based on four topics, all interconnected to PM, as one can see on figure 3. Prior to the interviews, the interview guide was pretested by both authors and adjusted accordingly. The interview guide can be found in the Appendix A.

Figure 3 - Interview Structure



The interviews' main goal was to prompt the respondents to describe the challenges they face in PM with questions such as “In your opinion, what is the main difficulty of Human Resources Management?”; “During the planning phase of a project, does your organization identify and manage requirements? Does this task present any difficulties or challenges?”. Each interview lasted for an average of 45 minutes. The recorded interviews were documented and qualitatively analysed using Microsoft Excel, as presented in the Appendix B.

3.2 Data Collection

24 PMOs of renowned Portuguese organizations were invited to participate in the interview. Out of 24 invitations, 12 interviews were performed in person or via electronic conference, yielding a response rate of 50%. The respondents were diverse in terms of the industry they are operating in and further regarding demographics such as age and gender.

Regarding company size, measured by the number of employees, the set of respondents is mostly composed of large companies (European Union, 2015), which comprises 92% of the total, Table 4. The distribution by industry, as previously mentioned, is highly dispersed with the largest one (Financial Services) comprising only 25% of the total, Table 5.

Table 4 - Number of Employees per Respondent Organization

<i>Number of employees</i>	Number of respondents	Percentage (%)
<i>0 - 249</i>	1	8%
<i>250 - 999</i>	4	33%
<i>1000 - 4999</i>	5	42%
<i>5000 - 14999</i>	2	17%
<i>15000 - 25000</i>	0	0%
<i>> 25000</i>	0	0%
Total	12	100%

Table 5 - Distribution of Respondents by Industry

<i>Industry</i>	Number of respondents	Percentage (%)
<i>Financial services</i>	3	25%
<i>Engineering & construction</i>	2	17%
<i>Government & public services</i>	2	17%
<i>Aerospace & aviation</i>	1	8%
<i>Energy & utilities</i>	1	8%
<i>Insurance</i>	1	8%
<i>Retailer & consumer</i>	1	8%
<i>Telecommunications</i>	1	8%
Total	12	100%

3.3 Data Analysis

Based on the interviews, Table 6 exhibits the number of identified pain points for each of the ten knowledge areas of PM, by the twelve respondents.

Table 6 - Identified Pain Points for each PM Knowledge Area

Knowledge Areas	Number of Identified Pain Points	Percentage (%)
<i>Human Resources</i>	10	83%
<i>Scope</i>	6	50%
<i>Procurement</i>	5	42%
<i>Risk</i>	4	33%
<i>Stakeholder</i>	3	25%
<i>Cost</i>	2	17%
<i>Quality</i>	2	17%
<i>Time</i>	1	8%
<i>Integration</i>	0	0%
<i>Communications</i>	0	0%
Total	33	N/A

The analysis of the interviews yields that on average, each respondent identified pain points in three knowledge areas. According to 83% of the respondents, Human Resources is the most critical area. As stated by the respondents, the pain points in Human Resources Management are related to team competency, culture and knowledge of PM, and also related to unclear roles and responsibilities.

Additionally, 50% of the respondents identified pain points in Scope Management, while 42% identified pain points in Procurement Management. Interviewees suggested that the pain points in Scope Management are related to unstable, unclear and incomplete requirements from the client and other stakeholders. Moreover, the pain points in

Procurement Management are due to bureaucracy and long waiting times in the different procurement processes.

Finally, four respondents identified pain points in Risk Management, while eight respondents stated that their organization does not perform Risk Management. This finding is especially interesting given that the lack of proactive risk management is one of the major challenges in projects according to Oehmen (2012). No pain points were reported for the knowledge areas of Integration and Communications Management.

3.4 Framework Development

Due to high failure rate of projects in practice, this research sought to find out the underlying reasons for projects going astray. Based on these pain points, the ensuing section proposes an amalgamation of PM knowledge areas and processes with suitable lean principles to overcome said impairment. More specifically, the current effort focuses on the three knowledge areas that appear to have more pain points: Human Resources Management, Scope Management and Procurement Management. Table 3 previously presented provides an overview of the most readily available lean techniques and tools that, in an adapted manner, introduce the six lean principles and provide a suitable extension to improve current PM.

3.4.1 Human Resources Management

According to the gathered data, Human Resources Management is the most challenging area in terms of pain points. Oehmen (2012) suggests that a Lean organization must recognize that its people are the most valuable asset. Critical pain points of Human Resources Management are related to challenges in team competency, culture and knowledge of PM, and unclear roles and responsibilities in the project. Table 7 identifies a set of initiatives, techniques and tools based on lean principles to amend these pain points relative to the related PM processes.

As an illustration of how the framework can be comprehended, it is suggested that in Human Resources Management value can be specified through the establishment of effective interaction with the different stakeholders, internal and external, throughout the entire project life cycle. This initiative aims to mitigate one of the identified pain points, namely the unclear roles and responsibilities in the project. Moreover, this can be achieved through a set of lean tools and techniques: the application of TQM, focused on continuous improvement employing participative management; an *Obeya* Room, directed

to dedicated space and time for coordination and problem-solving; Daily *Kaizen*, a status quo daily activity; or *Hoshin Kanri*, to assure the strategic goals of the organization and the project drive progress and action at every level.

3.4.2 *Scope Management*

Two thirds of the interviewed PMOs identified pain points in the Scope Management area. PM is adversely affected by clients' unstable priorities, an incomplete understanding of stakeholders' requirements and the inability of stakeholders to communicate their needs. Table 8 exhibits lean tools and techniques that support circumventing the challenges of Scope Management.

3.4.3 *Procurement Management*

Bottlenecks, which are process constraints that limit its flow, produce waste and are often caused by specific knowledge areas. According to the data, particularly the bureaucracy and waiting times are examples of bottlenecks in Procurement Management. It is essential for organizations to eliminate bottlenecks in order to improve flow and to optimize the entire process. Table 9 presents a set of initiatives to take action upon the pain points of Procurement Management.

Table 7 - Lean Project Management Framework - Human Resources Management

Lean Principle	Initiative	Pain Points	Tools and Techniques	PM Processes
Value	Establish effective interaction with internal and external stakeholders throughout the project life cycle	(3)	TQM, <i>Obeya</i> , Daily <i>Kaizen</i> , <i>Hoshin Kanri</i> , Team Work	9.1 Plan Human Resource Management 9.4 Manage Project Team
Value Stream	Map, in advance, all project members and assign roles and responsibilities based on individual skills	(1) and (3)	A3, Visual Controls, Cross-Functional Teams	9.1 Plan Human Resource Management 9.2 Acquire Project Team
	Define indicators and metrics to manage the project	(2) and (3)	Visual Controls, <i>Andon</i> , <i>Poka-Yoke</i> , <i>Kamishibai</i> , Daily <i>Kaizen</i>	9.1 Plan Human Resource Management 9.4 Manage Project Team
Flow	Develop a communication plan including the team and the stakeholders	(2) and (3)	Value Stream Map, A3, Visual Controls	9.1 Plan Human Resource Management
	Promote collaborative and inclusive decision making to resolve the root cause of issues	(1) and (3)	<i>Obeya</i> Room, PDCA, Root Cause Analysis, Team Work	9.4 Manage Project Team
	Make project progress visible to everyone	(2) and (3)	<i>Jidoka</i> , <i>Kanban</i> , Visual Controls, <i>Andon</i> , Daily <i>Kaizen</i>	9.1 Plan Human Resource Management 9.4 Manage Project Team
	Involve the top-level management and representatives of all parts of the organization in the project	(1) and (3)	<i>Hoshin Kanri</i> , <i>Genchi Genbutsu</i> , <i>Jishuken</i> , Daily <i>Kaizen</i>	9.1 Plan Human Resource Management
Pull	Foster the learning on the team, when they need it	(1) and (2)	<i>Kaizen</i> , TQM, Cross-Functional Teams	9.3 Develop Project Team
Perfection	Use the organization's instituted standards, procedures and guidelines effectively	(2)	Standardization, PDCA Cycle, 5S, <i>Kamishibai</i>	9.1 Plan Human Resource Management
	Perform and use lessons learned	(1)	Daily <i>Kaizen</i>	9.3 Develop Project Team
	Aim for flawless communication, coordination and collaboration across people and processes	(2) and (3)	A3, <i>Obeya</i> , <i>Kamishibai</i>	9.1 Plan Human Resource Management
Respect for People	Ensure that everyone's contribution to the project goals is visible	(1) and (3)	Visual Controls, <i>Andon</i> , <i>Obeya</i>	9.1 Plan Human Resource Management 9.4 Manage Project Team
	Empower project members to accept responsibility and take action	(1) and (3)	TQM, <i>Hoshin Kanri</i>	9.3 Develop Project Team
	Promote and establish the ground for professional excellence and career plans, with rewards based upon performance	(1)	<i>Kaizen</i> , TQM, Cross-Functional Teams	9.2 Acquire Project Team 9.3 Develop Project Team
	(1) – team competency (2) – culture and knowledge of PM (3) – unclear roles and responsibilities in the project			

Table 8 - Lean Project Management Framework - Scope Management

Lean Principle	Initiative	Pain Points	Tools and Techniques	PM Processes
<i>Value</i>	Identify, clarify and prioritize requirements early, often and proactively, including only what creates value	(1), (2) and (3)	<i>A3, Obeya, Yamazumi Chart</i>	5.2 Collect Requirements 5.3 Define Scope
<i>Value Stream</i>	Map the value stream and eliminate non-value-added elements	(1)	Value Stream Map, <i>Yamazumi Chart</i>	5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS
	Reduce the focus to a small subset of requirements, which are accurately defined	(2) and (3)	<i>Heijunka, Value Stream Map, A3</i>	5.3 Define Scope 5.4 Create WBS
	Define indicators and metrics to manage the project	(1)	Visual Controls, <i>Andon, Poka-Yoke, Kamishibai, Daily Kaizen</i>	5.1 Plan Scope Management 5.6 Control Scope
<i>Flow</i>	Promote collaborative and inclusive decision making to resolve the root cause of issues	(1), (2) and (3)	<i>Obeya Room, PDCA, Root Cause Analysis</i>	5.1 Plan Scope Management 5.6 Control Scope
	Ensure a transparent role division in terms of responsibility, accountability and authority throughout the project	(1)	Value Stream Map, A3, Visual Controls	5.1 Plan Scope Management
	Make project progress visible to everyone	(1)	<i>Jidoka, Kanban, Visual Controls, Andon, Daily Kaizen</i>	5.1 Plan Scope Management 5.6 Control Scope
<i>Pull</i>	Pull tasks and outputs based on project demand and eliminate what does not add value	(1)	Value Stream Map, <i>Kanban, JIT</i>	5.5 Validate Scope 5.6 Control Scope
<i>Perfection</i>	Use the organization's instituted standards, procedures and guidelines effectively	(1)	Standardization, PDCA Cycle, <i>5S, Kamishibai</i>	5.1 Plan Scope Management
	Effectively manage change requests	(1), (2) and (3)	PDCA, A3, Root Cause Analysis	5.6 Control Scope
<i>Respect for People</i>	Engage and sustain extensive stakeholder interactions	(1), (2) and (3)	TQM, <i>Obeya, Daily Kaizen, Hoshin Kanri</i>	5.1 Plan Scope Management
	(1) – clients' unstable priorities (2) – incomplete understanding of stakeholders' requirement (3) – inability of stakeholders to communicate their needs			

Table 9 - Lean Project Management Framework - Procurement Management

Lean Principle	Initiative	Pain Points	Tools and Techniques	PM Processes
Value	Identify, describe and detail requirements in the Request For Proposal for the suppliers	(2)	A3, <i>Obeya</i> , <i>Yamazumi</i> Chart	12.2 Conduct Procurements
	Actively minimize the bureaucracy	(2)	<i>Kaizen</i> , Value Stream Map, <i>Jishuken</i>	12.1 Plan Procurement Management 12.2 Conduct Procurements
Value Stream	Develop a procurement management plan with assigned roles and responsibilities	(1) and (2)	Value Stream Map, A3, Visual Controls	12.1 Plan Procurement Management
	Work with suppliers to proactively identify and mitigate conflicts and risks	(1) and (2)	<i>Jishuken</i> , PDCA, <i>Kanban</i> , Supplier Involvement	12.2 Conduct Procurements 12.3 Control Procurements
Flow	Ensure a transparent role division in terms of responsibility, accountability and authority throughout the project	(2)	Value Stream Map, A3, Visual Controls	12.1 Plan Procurement Management
	Promote collaborative and inclusive decision making to resolve the root cause of issues	(1) and (2)	<i>Obeya</i> Room, PDCA, Root Cause Analysis	12.1 Plan Procurement Management 12.3 Control Procurements 12.4 Close Procurements
Pull	Interact with the suppliers during execution	(2)	Supplier Involvement, <i>Obeya</i> , Daily <i>Kaizen</i> , <i>Hoshin Kanri</i>	12.3 Control Procurements
Perfection	Use the organization's established standards, procedures and guidelines effectively	(1)	Standardization, PDCA Cycle, <i>5S</i> , <i>Kamishibai</i>	12.1 Plan Procurement Management
Respect for People	Promote close collaboration between internal customers and suppliers	(2)	Supplier Involvement, <i>Obeya</i> , Daily <i>Kaizen</i> , <i>Hoshin Kanri</i> , Team Work	12.1 Plan Procurement Management 12.3 Control Procurements
	(1) - bureaucracy (2) – waiting times			

4 Stage 2 - Lean Project Management Framework Validation

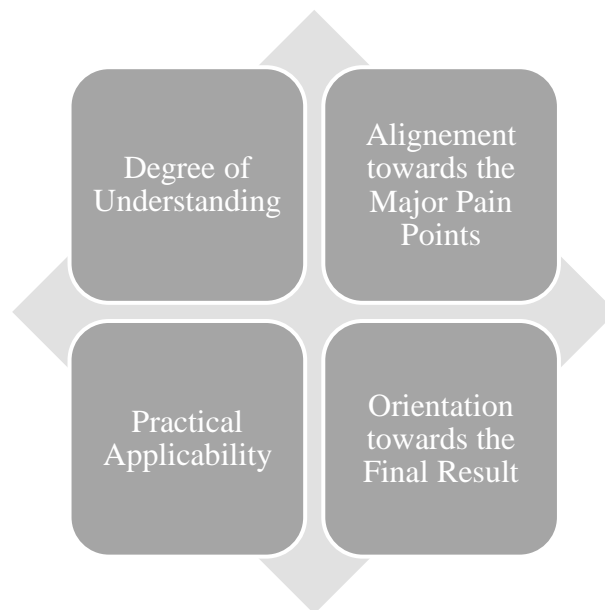
Following the initial development of a Lean Project Management Framework, it is essential to further validate the suggested framework in order to answer the dissertation research problem, the application of lean principles to project management, in order to improve projects performance. Therefore, the ensuing sections present the methodology and results of validating the Lean Project Management Framework.

4.1 Methodology

The present study intends to validate the framework through experts' feedback. In this field, PMOs and top level project managers of renowned Portuguese organizations are considered the experts. The feedback was gathered via a second semi-structured interview.

The experts' feedback aims to validate the framework based on the four different pillars illustrated in Figure 4: degree of understanding; alignment towards the major pain points in PM; practical applicability; and orientation towards the final result of a project. The interviews commenced by describing and explaining the suggested lean tools and techniques to the interviewees, followed by an examination of the proposed framework for each of the three knowledge areas, ending with a set of questions related to the four pillars. Prior to the interviews, the interview guide was pretested by both authors and adjusted for language accordingly. The interview guide can be found in the Appendix C.

Figure 4 - Four pillars of the framework validation



4.2 Data Collection

For this second round of interviews, a follow-up email was written to the respondents of the first interview; thus, twenty-four individuals were invited to participate in the interview. Out of twenty-four invitations, eight interviews were performed in person or via electronic conference, yielding a response rate of 33%. Seven of the respondents had already participated in the first round of interviews, while one respondent was introduced to the topic for the first time. Participants had diverse industry backgrounds, and were representative in terms of demographics, such as age and gender. Each interview lasted on average for 30 minutes. The recorded interviews were documented and qualitatively analysed using Microsoft Excel, as presented in the Appendix D.

Regarding company size, defined by the number of employees, the set of respondents is composed to 87% of large companies (European Union, 2015) as Table 10 illustrates. The distribution by industry is highly dispersed with the largest three sectors - Energy & utilities, Engineering & construction, and Government & public services - comprising 25% of the total sample (Table 11).

Table 10 - Number of Employees per Respondent Organization

<i>Number of employees</i>	Number of respondents	Percentage (%)
<i>0 - 249</i>	1	12,5%
<i>250 - 999</i>	2	25%
<i>1000 - 4999</i>	4	50%
<i>5000 - 14999</i>	1	12,5%
<i>15000 - 25000</i>	0	0%
<i>> 25000</i>	0	0%

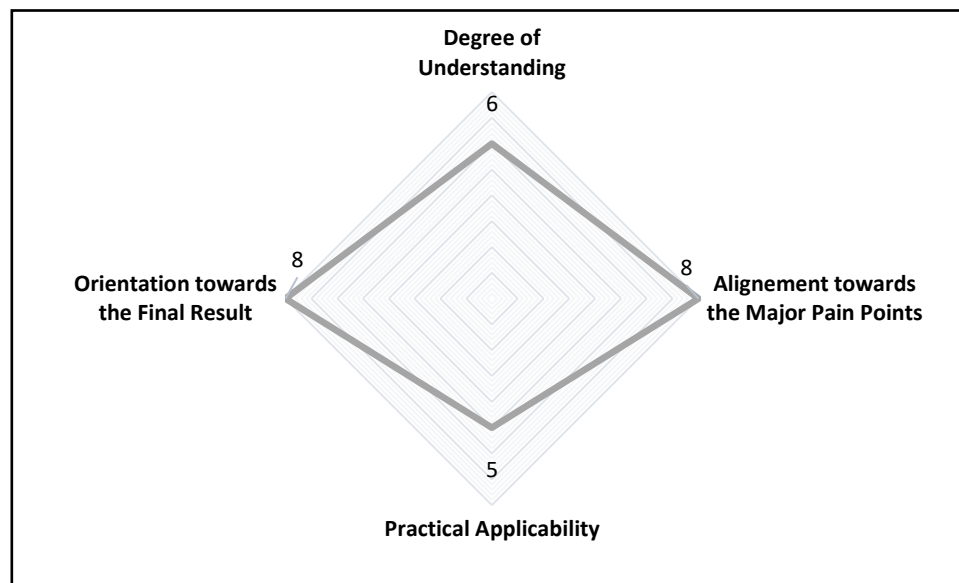
Table 11 - Distribution of Respondents by Industry

<i>Industry</i>	Number of respondents	Percentage (%)
<i>Energy & utilities</i>	2	25%
<i>Engineering & construction</i>	2	25%
<i>Government & public services</i>	2	25%
<i>Aerospace & aviation</i>	1	12,5%
<i>Financial services</i>	1	12,5%
Total	8	100%

4.3 Data Analysis

Based on the interviews, Figure 5 exhibits the experts' feedback on each of the four pillars: degree of understanding, alignment towards the major pain points in PM, practical applicability, and orientation towards the final result of a project. The framework was validated considering the number of interviewed PMOs that confer validity to each of the pillars. Thus, in case all the PMOs recognize the validity of the Lean Project Management in one pillar, it will have a score of 8.

Figure 5 - Lean Project Management Framework Validation Results



The interview analysis evidences that all respondents concede that the framework is aligned with the major pain points in PM. However, this research has only developed the Lean Project Management Framework for three out ten knowledge areas of PM. While these three areas are evidenced as the most critical ones by PMOs, not every interviewed PMO identifies his organization's major pain points with these knowledge areas. Consequently, 37,5% of the PMOs suggest the extension of the framework to the remaining knowledge areas.

Additionally, 100% of the interviewees agree that the framework is oriented towards ultimate goal of project success. The framework is viewed as a valuable asset for organizations, being able to eliminate bottlenecks and improve project performance.

Regarding the understanding of the framework, 75% of the respondents recognize that the framework is easy and simple to understand, On the contrary, 25% deem the

framework as very theoretical and as being conditioned to prior knowledge of lean principles and tools.

Finally, 62,5% of the respondents claim that the framework can be put into practice. Yet, 75% of the respondents suggest the development of a framework dictionary, detailing how each lean tool and technique can be operationalized. The dictionary should further classify the tools and techniques in terms of effort level and correlation to the project size, in order to simplify and speed up the task of putting the framework into practice.

5 Discussion and Implications

5.1 Discussion

This dissertation proposes a Lean Project Management framework to accelerate the performance of projects by joining PM practices and lean principles. This study is composed of two stages. During Stage 1, interviews with PMOs of renowned Portuguese organizations are conducted, aiming to identify the knowledge areas with most pain points. Following the identification of the areas with critical pain points, a Lean Project Management Framework is developed with the aim of reducing the identified pain points. Throughout Stage 2, the proposed framework is validated through a second set of interviews along four pillars.

The interviews of Stage 1 evidence that on average respondents identified pain points in three knowledge areas. In line with PMI (2016) and PMI (2015), these results show that PM still contains several challenges and pain points, even though organisations have been collecting years of experience in managing projects. As for the three knowledge areas with most pain points: 83% of the respondents consider Human Resources Management as having most pain points, 50% believe Scope Management to contain several critical pain points, and finally 42% deem Procurement Management as still incorporating many critical pain points.

According to the interviewees, the pain points in Human Resources Management are related to competency of the team members, and culture and knowledge of PM. Further shortcomings in Human Resources Management are unclear roles and responsibilities of project members. The pain points in Scope Management are related to unstable, unclear, and incomplete requirements from the client and other stakeholders. In Procurement Management, the identified pain points are due to bureaucracy and long waiting times in the different procurement processes. Scrutinizing the similarities of pain points across all three knowledge areas in more detail, evidences that most, if not all, critical pain points are interconnected and have one element in common—people. This finding corresponds to Oehmen (2012), who insinuate that people are the most important asset of an organization and they should be respected, trusted, motivated and rewarded as such.

Besides Human Resources Management, Procurement Management, and Scope Management—the three knowledge areas with most identified pain points— Stage 1 further evidences essential findings in relation to Risk Management. In the Risk Management knowledge area, four respondents stated that their organization does not

implement any notions of Risk Management, while another three PMOs indicated that the maturity level in this knowledge area is very low. These results show that there is a need for further knowledge development on Risk Management for organisations, which is in line with Oehmen (2012), who suggest that the lack of proactive risk management is one of the major challenges in projects.

Interestingly, out of ten knowledge areas, PMOs did not report any pain points for only two areas, namely for Integration and Communications Management. The first relates to the coordination and integration of all elements of the project, and the latter concerns the documentation of information. A potential explanation for both areas not containing any pain points, is that these areas do not experience the volatile aspect of people, but are rather streamlined functions. Linking back to the three knowledge areas with most identified pain points, the most poignant difference is that these three involve a large people component, be it in terms of team members or regarding the client, that brings with it increasing uncertainty. On the contrary, Integration and Communications Management incorporates rather bureaucratic aspects that can be streamlined by organisations and hence experience less volatility and uncertainty, leading to less critical pain points in their management.

In response to the identified pain points during the interviews, the author develops the Lean Project Management Framework, which seeks to remedy the challenges in the three most critical knowledge areas. Hence, the ultimate goal of the Lean Project Management Framework is to accelerate project performance through PM practices and lean principles. The framework suggests a set of tools and techniques for each of the six lean principles, and relates them to specific PM processes. Through that, a number of initiatives are developed that support PMOs to remedy the existing pain points for Human Resources Management, Scope Management, and Procurement Management.

After Stage 1 of this thesis focused on developing the Lean Project Management Framework based on interviews with PMOs, Stage 2 validated the framework through another series of interviews. The interviews aimed to validate the framework on four pillars: alignment towards the major pain points, orientation towards the final result, degree of understanding, and practical applicability. Regarding the first pillar, all PMOs validated the alignment and coverage of the Lean Project Management Framework with the major pain points of Human Resources Management, Scope Management, and Procurement Management. The application and alignment of the Lean Project

Management Framework to each of the three knowledge areas' pain points is discussed in more detail, as follows.

The critical pain points of Human Resources Management are related to challenges in team competency and culture and knowledge of PM, which ultimately leads to unclear roles and responsibilities in the project. The interviewed PMOs consent that the Lean Project Management Framework can aid them in amending the critical pain points through initiatives like mapping all project members and assigning roles and responsibilities based on individual skills. The framework supports PMOs by providing selected tools and techniques for each initiative, for instance the application of A3 and visual controls. Another initiative for Human Resources Management is to foster the required learning and education for team members, which can be operationalized through the tools and techniques of *Kaizen* and TQM. Finally, PMOs also agree with the framework in suggesting that pain points of Human Resources Management can be amended by empowering project members to accept responsibility and take action, which can be fostered through TQM and *Hoshin Kanri*.

For Scope Management, the identified pain points include clients' unstable priorities, incomplete understanding of stakeholders' requirements, and the inability of stakeholders to communicate their needs. PMOs confirm that the framework's initiative of identifying, clarifying, and prioritizing requirements—early, often, and proactively—has the potential to amend several of these critical pain points. This initiative can be operationalized through the tools and techniques of A3, *Obeya* Room or the *Yamazumi* Chart tools. Another essential initiative to lessen pain points in Scope Management is to define metrics and indicators to manage and control the project, through visual controls or *Andons*.

Identified pain points of Procurement Management include long waiting times and bureaucracy in the procurement processes. Following the Lean Project Management Framework, PMOs endorse that interacting with the suppliers during the execution, operationalized through the technique of TQM, can support Procurement Management in reducing waiting times. Additionally, PMOs agree that the technique of *Kaizen* can aid them in actively minimizing bureaucracy. Overall, PMOs concur that the framework's initiatives and corresponding tools and techniques of the six lean principles are valuable in reducing the critical pain points in Human Resources Management, Scope Management, and Procurement Management.

Regarding the second pillar of validating the framework—orientation towards the final result of project success—all PMOs consent that the lean initiatives, and tools and techniques for the respective PM processes, are oriented towards accelerating project performance.

Finally, concerning the third and fourth pillar, degree of understanding and practical applicability, some respondents suggested that the framework is complex to understand. PMOs insinuated that a prerequisite for practically applying the framework is up-front lean and PM knowledge. Nonetheless, they proposed that this potential shortcoming can be overcome by the development of a framework dictionary to improve theoretical understanding and practical applicability.

In conclusion, the PMOs reflected positively on the developed Lean Project Management Framework to reduce critical pain points in Human Resources Management, Scope Management, and Procurement Managements. PMOs confirmed the framework's alignment with the major pain points and its orientation towards accelerating project success. More elaborate guidelines on how to implement the framework will strengthen these aspects even more.

5.2 Research Implications

This research adds important aspects to the existing literature of PM and Lean Thinking. The results provide two salient contributions affecting the performance of PM and the success of projects. First, there are several knowledge areas that contain a diverse set of pain points for PMOs. The most critical knowledge areas are Human Resources Management, Scope Management, and Procurement Management. These findings extend prior research that point towards Human Resources Management as one of the most challenging areas in PM (Huemann *et al.*, 2007; Matta and Ashkenas, 2003), and the criticality of Scope Management (Nielsen & Almlie, 2010). On the contrary, prior research has paid less attention to the importance of Procurement Management, which this study identifies as one of the most critical areas in terms of absolute number of pain points. PMOs emphasize the problematic of bureaucracy and long waiting times in procurement processes, which require more theoretical investigation and empirical examination.

Second, by continuously identifying and evaluating improvement opportunities in PM processes, waste can be reduced, and a wholesome flow can be enabled. As apparent from

the high failure rates of projects in practice, further research on how to improve PM is not only desired but a necessity. Anholon and Sano (2016) assessed lean projects using PM guidelines, analysing the most critical processes; Oehmen (2012) identified the major challenges in programs or projects as well as 43 lean enablers to overcome these challenges, showing that the use of lean results in a significant stronger performance in all dimensions of PM and projects; and finally, Tenera and Pinto (2014) integrated lean, six-sigma and PM aiming for continuous improvement of the PM processes. The current research aims to extend these publications by suggesting that a Lean Project Management approach can amend specific pain points of PM knowledge areas. More specifically, the use of traditional lean tools adapted to the PM context can aid in the continuous improvement of processes and practices by conferring role clarity, transparency, and reducing bottlenecks. Therefore, this study suggests that Lean Project Management provides a viable approach to overcome the shortcomings of traditional PM practices, adding an important aspect to the existing literature in this field of studies (Anholon and Sano, 2016; Oehmen, 2012; Tenera and Pinto, 2014).

5.3 Managerial Implications

Based on the findings of this study, several essential implications for project managers and PMOs are drawn. The amalgamation of PM knowledge areas and processes with suitable lean principles as suggested by the developed framework, and acknowledged by experts, brings benefits for the organizations in various forms. First, the Lean Project Management Framework is aligned with the major pain points in PM knowledge areas and supports PMOs by providing an overview of initiatives to remedy pain points and further supplying guidelines on how to operationalize them.

Second, the Lean Project Management Framework is oriented towards the acceleration of project success. The holistic and multidimensional nature of the framework emphasizes that lean tools and practices should not be implemented in isolation, but rather complementarily to other features of Lean Thinking. It is the unified and interrelated effect of all lean principles, practices, and tools as a whole that makes lean such a forceful tool in supporting organizations to achieve successful results (Shah & Ward, 2007). While a committed project manager is important when implementing the Lean Project Management Framework, it is essential to further have the approval and support of the top management in implementing the framework and Lean Thinking in

projects. Only through top-down and bottom-up understanding and support can the organization and projects benefit from the merger of PM practices and Lean Thinking.

Another important contribution for managers is the centrality of people and the significance of respecting them. PMOs highlighted the prominence of the sixth lean principle—respect for people—by stressing that everyone’s contribution should be visible and people should be empowered to accept responsibility and take action. The importance of the sixth lean principle is often overlooked, yet people are the most important asset of an organization and should be respected, motivated, and rewarded as such (Oehmen, 2012).

In summary, the empirical results of this study support the theoretical benefits attributed to Lean Thinking, in that Lean Thinking may contribute to leverage the performance and the success rate of projects. Nonetheless, Lean Thinking in PM has to be put into practice through a validated and firm-internally approved framework to reap its advantages.

5.4 Further Research and Limitations

There are several limitations of this research. One limitation is the small sample size, restricted to participants solely from Portugal, which limits generalizability. To mature knowledge on lean principles in PM, it would be valuable to scrutinize the pain points of PMOs for other cultural and geographical spheres, and to extend the Lean Project Management Framework complementarily.

The second limitation of this study regards the PMOs feedback for the framework validation. Empirically applying and testing the framework might lead to yet different adaptations to the Lean Project Management Framework. Further research should examine the proposed Lean Project Management Framework in practice and refine it accordingly. It is essential to empirically detail and cultivate the suggested lean tools and techniques in accordance with the PM knowledge areas and processes, in order to eventually leverage project success.

The third limitation regards the PM maturity level of each organization. This study focused on the identification of the organization’s PM pain points yet different PM maturity levels might lead to different pain points. Further research should examine the relationship between PM maturity level and the identified pain points, with the intention of reinforcing the Lean Project Management Framework.

Fourth, this research has only developed the Lean Project Management Framework for three out ten knowledge areas of PM. While these three areas are evidenced as the most critical ones by PMOs, further research on lean project management would benefit from extending the framework to the other seven knowledge areas as well.

Fifth, PMOs stressed the advantages of creating a framework dictionary that details each initiative, tool, and technique, and how they can be put into practice. Such a dictionary would facilitate the theoretical understanding and practical introduction of the Lean Project Management Framework considerably.

Finally, a fruitful avenue for future research is to investigate the effect of the organization's lean culture on the Lean Project Management Framework implementation, in order to examine the level of dependency between the outcomes of the framework and prior Lean Thinking knowledge.

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Corresponding appendices

Appendix A – Stage 1: Interview Guide for the Framework Development

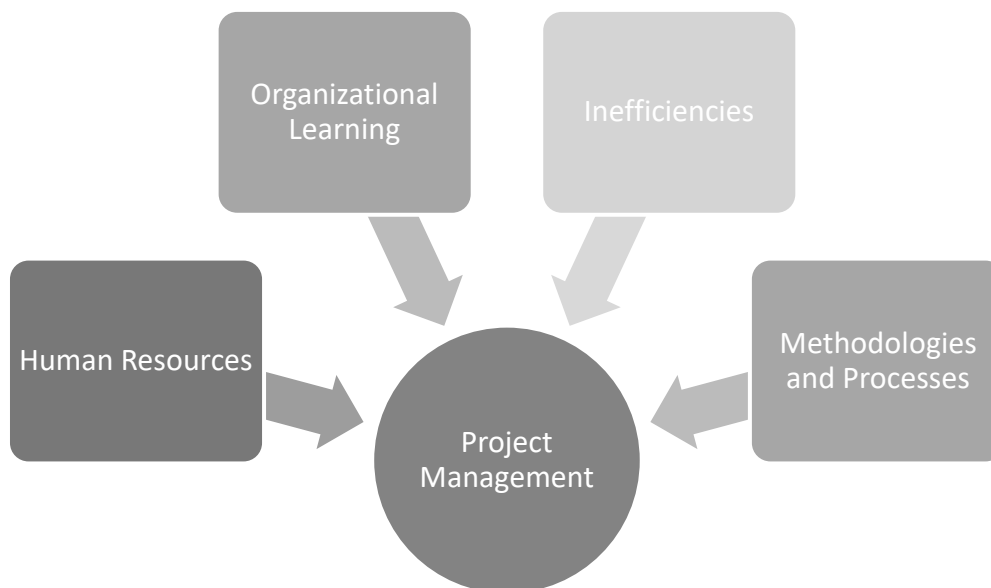
Introduction

Although organizations appear to be identical, they operate according to different Project Management practices and processes. Therefore, the focus of the present study is to understand these differences and, in turn, to understand the Project Management main difficulties encountered during the life cycle of a project.

Thus, the present dissertation falls within the area of Project Management and its title is **“Lean Project Management – Application of Lean Principles to Project Management”**. The dissertation seeks to apply lean principles to Project Management in order to improve projects performance.

The current interview is based on the following four topics, related to Project Management, whereas a few questions related to which one will be asked:

Figure 1. Interview Structure



The authors would like to point out that all the collected data will be treated confidentially, and the final results can be shared if requested by the respondents. It should be also mentioned that the present study will not include any rankings and the only information regarding the different companies is about their collaboration.

Context

1. What is the name of your Organization and how many employees does the Organization have in Portugal?
2. In how many countries is the Organization present?
3. In which sector is the Organization currently operating?

I. Human Resources

1. Since there are several types of organizational structures, which type of structure does your Organization have? Is there a Project Management Office in your Organization? (PSO, PMO, PrgMO, CPO)

2. Regarding the project team, are the team members allocated solely to one project? And in your opinion, do they identify themselves more with the project they are working on or with their functional area, in case they are originally from one?

3. Regarding the competencies of the project team, which type of training or Project Management knowledge do the members have?

4. The environment created by the Organization and the support of the managers is considered fundamental for the motivation and the performance of every employee and project team. Do the employees show initiative and/or are motivated to be proactive and create projects for the Organization? Do the managers support the employees and the use of Project Management processes? On the other hand, are the employees motivated to improve procedures and processes of the Organization?

II. Project Management Methodologies and Processes, Organization Learning and Inefficiencies

1. Does your Organization have Project Management methods and processes? On the other hand, is your Organization aware of or aligned with the so-called best practices of Project Management? (PMBoK, AIPM, IPMA)
2. Regarding the different methodologies and processes in use, are they adopted by the employees? If not, do you find any justification for this fact? In your opinion, what is the main difficulty of Human Resources Management?
3. During the planning phase of a project, does your organization identify and manage requirements? Does this task present any difficulties or challenges? Are the possible difficulties related to Stakeholder or Communications Management? And how can this process be simplified or improved?
4. Still in the planning phase, are good practices adopted in terms of scope, cost and time? If so, which ones? On the other hand, what do you consider to be best planned or controlled, the cost? And usually, which topic brings more problems? Are the mentioned problems somehow related to Human Resources?
5. Is Quality Management and Control performed in your Organization? Can you identify some inefficiencies or difficulties in this task? And regarding Risk Management and Control?

6. Regarding the contact with other entities, is the Procurement performed according to the best practices? Usually, what works well and what does not? Are the possible problems related to the bureaucracy connected to the process?

7. Change Requests are a hot topic in Project Management. How does your Organization deal with this topic? And how are changes implemented?

8. During the course of a project, what are the major difficulties encountered in the Monitoring and Control processes? Are these considered complex processes or tasks? If so, do you think it is possible to simplify these tasks? In what way?

9. Does the project team gather, document and share project, program or portfolio lessons learned? Does the Organization incorporate these lessons learned into its processes of organizational learning? (*Tailoring*)

10. Has the Organization implemented any process of continuous improvement? Is this topic known, addressed or used?

11. Lastly, what do you consider to be the main Project Management difficulty or problem within your Organization?

V. FUTURE

1. In your opinion, could Lean principles solve some of the inefficiencies encountered in Project Management processes within your Organization?

----- END -----

Appendix B – Stage 1: Data Analysis of the Framework Development Interviews

Major Pain Points						
	Organization A	Organization B	Organization C	Organization D	Organization E	Organization F
	HR - lack of competences and motivation in the team	HR - difficulty in managing people	HR - methodologies and good practices not implemented and followed in every area of the organization	HR - lack of competences in PM good practices, processes and tools, and lack of motivation to apply it	Planning phase often finishes too early due to pressure from top management	Scope - difficulty in defining the requirements with the client
	Procurement - bureaucracy and long waiting times	Risk - Does not perform Risk Management	Scope - difficulty in defining and closing the requirements	Scope - change request by the client is common, and it does not follow the change request process	Scope - Difficulty in closing the scope	Cost - Does not have a management methodology
			Procurement - bureaucracy and long waiting times	Risk - Does not perform Risk Management		Procurement - bureaucracy and long waiting times
Knowledge Areas						
Integration						
Scope			1	1	1	1
Time						
Cost						1
Quality						
HR	1	1	1	1		
Communications						
Risk		1		1		
Procurement	1		1			1
Stakeholder					1	

	Organization G	Organization H	Organization I	Organization J	Organization K	Organization L
	Scope - Difficulty in closing the scope	HR - limited resources	HR - lack of competences and difficulties on the adoption of procedures	HR - lack of resources and competences in PM	Procurement - bureaucracy and long waiting times	HR - limited internal resources
	HR - difficulties in the adoption of the methodologies and management of people by the project manager	Scope - difficulty in defining and closing the requirements, leading to change requests	Time - difficulties planning connected to the HR competences and the adoption of PM practices	Risk - Does not perform Risk Management	HR - lack of PM competences and difficulties managing capacity	Scope - difficulty in defining and closing the requirements, leading to change requests
	Risk - Not performed according to the best practices	Quality - Does not perform Quality Management	Risk - very low maturity level		Risk - very low maturity level	Quality - Does not perform Quality Management
		Risk - very low maturity level			Cost – difficulty planning to the lack of competences	Risk - very low maturity level
						Procurement - bureaucracy and long waiting times
	Knowledge Areas					
Integration						
Scope	1	1				
Time			1			
Cost					1	
Quality		1				1
HR	1	1	1	1	1	1
Communications						
Risk	1	1	1	1	1	1
Procurement					1	1
Stakeholder						1

Appendix C – Stage 2: Interview Guide for the Framework Validation

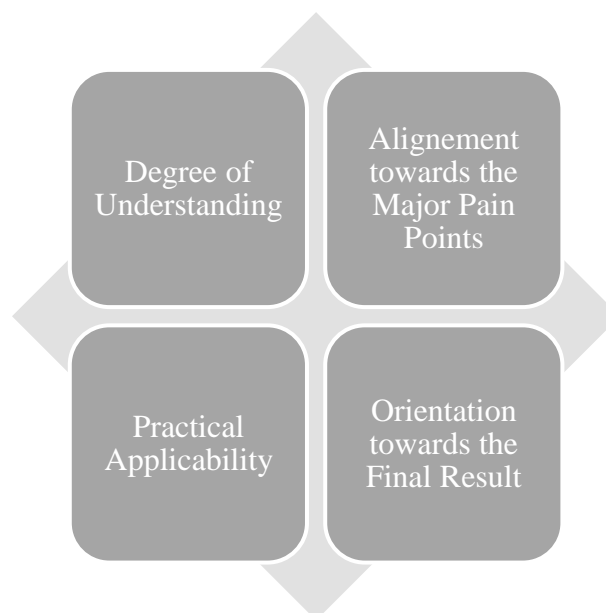
Introduction

The first stage of interviews of the present dissertation, “**Lean Project Management – Application of Lean Principles to Project Management**”, aimed specifically at discerning the structures of established Project Management (PM) processes and the challenges inherent to them for each of the questioned organizations. Another goal was to inquire the challenges pertaining to each one of the ten PM knowledge areas.

Based on the identified pain points, an amalgamation of PM knowledge areas and processes with suitable lean principles to overcome said impairment was performed and a framework developed. The developed framework aims to provide a viable approach to overcome the shortcomings of traditional PM practices and improve the success of projects.

Therefore, the present interview intends to validate the framework through experts’ feedback, hence through the feedback of PMOs of renowned Portuguese organizations. The interview aims to validate the framework on four different pillars: degree of understanding; alignment towards the major pain points in PM; practical applicability; and orientation towards the final result of a project.

Figure 1. Four pillars of the framework validation



The authors would like to point out that all the collected data will be treated confidentially, and the final results can be shared if requested by the respondents. It

should be also mentioned that the present study will not include any rankings and the only information regarding the different companies is about their collaboration.

Context

4. What is the name of your Organization and how many employees does the Organization have in Portugal?
5. In how many countries is the Organization present?
6. In which sector is the Organization currently operating?

Lean Project Management

The analysis of the interviews yields that on average, each respondent identified pain points in three knowledge areas. According to 83% of the respondents, Human Resources is the most critical area. As stated by the respondents, the pain points in Human Resources Management are related to team competency, culture and knowledge of PM, and also related to unclear roles and responsibilities.

Additionally, 50% of the respondents identified pain points in Scope Management, while 42% identified pain points in Procurement Management. Interviewees suggested that the pain points in Scope Management are related to unstable, unclear and incomplete requirements from the client and other stakeholders. Moreover, the pain points in Procurement Management are due to bureaucracy and long waiting times in the different procurement processes.

Therefore, the proposed framework gathers the mentioned three knowledge areas and their corresponding processes with lean principles and the most readily available lean techniques and tools (Table 1), that, in an adapted manner, provide a suitable extension to mitigate the identified pain points and improve current PM.

1. By analysing the proposed framework, do you consider it easy to understand? If not, in your opinion what is the main difficulty? Are the possible mentioned difficulties somehow related to a lack of knowledge about Lean methodologies and principles?
2. Does the framework approach the major pain points in Project Management? And how can this framework be improved?
3. In your opinion, does the framework have practical applicability? If not, what do you think is missing so it can be put into practice?
4. Does the framework add value and improve projects performance? Does it help to achieve the final result?

Table 1. Lean Techniques and Tools

<i>Techniques and Tools</i>	<i>Description</i>	<i>References</i>
5S	Focuses on effective work place organization and standardized work procedures.	Abdulmalek & Rajgopal (2007), Sugimori <i>et al.</i> , (1977) and Womack & Jones (1996)
A3	A visual method for communicating only pertinent information like proposal, problem solving, status reporting and competitive analysis.	Liker & Morgan (2006) and Moreci (2014)
<i>Andon</i>	The use of visual controls, such as overhead displays or electronic dashboards, to briefly convey the status quo of the work.	Liker (2004), Ohno (1988) and Womack & Jones (1996)
<i>Cross-Functional Teams</i>	The aim is to have team members who are able to perform different tasks in order to increase flexibility and reduce variability and risk exposure.	Shah & Ward (2003) and Sugimori <i>et al.</i> , (1977)
<i>Genchi Genbutsu</i>	Encourages workers, team leaders, and executives to go to the <i>Gemba</i> (the place in reality), to inquire a problem directly and work collectively on a solution	Liker & Morgan (2006)
<i>Heijunka</i>	Aims at levelling, because when the work load is leveled, there are opportunities for standardized processes.	Liker (2004), Ohno (1988), Sugimori <i>et al.</i> , (1977) and Womack & Jones (1996)
<i>Hoshin Kanri</i>	A method for ensuring that the strategic goals of a company drive progress and action at every level, aiming to eliminate the waste that comes from inconsistent direction and poor communication	Liker (2004) and Womack & Jones (1996)
<i>Jishuken</i>	A method of gathering managers for problem solving in the production process and continuous improvement	Marksberry <i>et al.</i> (2010)
<i>JIT</i>	Just-In-Time (JIT) concentrates on producing the right product at the right time.	Ohno (1988), Sugimori <i>et al.</i> , (1977), Womack & Jones (1996)
<i>(Daily) Kaizen</i>	An approach for continuous improvement, where Daily <i>Kaizen</i> acts as a daily activity.	Liker (2004), Ohno (1988) and Womack & Jones (1996)
<i>Kamishibai Boards</i>	A visual control for performing internal audits of processes or systems, aiming to train people to understand problems and find possible improvements.	Niederstadt (2013)
<i>Kanban</i>	A way to communicate between processes through a signaling system to help implement a pull system and to achieve a continuous flow.	Abdulmalek & Rajgopal (2007), Sugimori <i>et al.</i> , (1977), Womack & Jones (1996)
<i>Obeya Room</i>	A system that provides dedicated space, as well as time, for coordination and problem-solving, designed to minimize organizational barriers.	Liker & Morgan (2006)

<i>PDCA</i>	PDCA (Plan, Do, Check and Act) is an iterative methodology to propose a change in the process, implement it, measure the results and take appropriate action.	Moen & Norman (2006)
<i>Poka-Yoke</i>	Meaning “mistake-proofing” encourages the use of a range of low-cost, highly reliable devices throughout the different processes to prevent defects.	Liker (2004) and Ohno (1988)
<i>Root cause analysis</i>	An iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem (e.g. 5 Whys, Ishikawa Diagram).	Liker (2004), Ohno (1988) and Womack & Jones (1996)
<i>Standardized Work</i>	Setting a standard and bringing a condition into conformance with that standard, makes it possible for everyone to know what to do and when to do it.	Liker (2004) and Ohno (1988)
<i>Supplier Involvement</i>	A form of vertical collaboration with the suppliers to ensure alignment and accountability throughout the project cycle.	Liker (2004) and Womack & Jones (1996)
<i>Teamwork</i>	Building strong teams facilitates initiatives, which enables more consistent working and the elimination of waste.	Liker (2004), Ohno (1988) and Womack & Jones (1996)
<i>TQM</i>	Total Quality Management (TQM) is a system of continuous improvement that employs participative management techniques centered on the needs of customers.	Abdulmalek & Rajgopal (2007) and Shah & Ward (2003)
<i>Value stream mapping</i>	This approach intends to visually map the actual and future state of processes to highlight opportunities for improvement.	Abdulmalek & Rajgopal (2007), Womack & Jones (1996)
<i>Visual Controls</i>	Visual indicators, displays, dashboards or controls used to improve communication of information, by making it easily accessible and clear, to everyone.	Liker (2004) and Ohno (1988)
<i>Yamazumi Chart</i>	The Yamazumi Chart graphically represents tasks or workloads for optimization purposes.	Rahani & Al-Ashraf (2012)

Table 2. Lean Project Management Framework - Human Resources Management

Lean Principle	Initiative	Pain Points	Tools and Techniques	PM Processes
<i>Value</i>	Identify, clarify and prioritize requirements early, often and proactively, including only what creates value	(1), (2) and (3)	<i>A3, Obeya, Yamazumi Chart</i>	5.2 Collect Requirements 5.3 Define Scope
<i>Value Stream</i>	Map the value stream and eliminate non-value-added elements	(1)	Value Stream Map, <i>Yamazumi Chart</i>	5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS
	Reduce the focus to a small subset of requirements, which are accurately defined	(2) and (3)	<i>Heijunka, Value Stream Map, A3</i>	5.3 Define Scope 5.4 Create WBS
	Define indicators and metrics to manage the project	(1)	Visual Controls, <i>Andon, Poka-Yoke, Kamishibai, Daily Kaizen</i>	5.1 Plan Scope Management 5.6 Control Scope
<i>Flow</i>	Promote collaborative and inclusive decision making to resolve the root cause of issues	(1), (2) and (3)	<i>Obeya Room, PDCA, Root Cause Analysis</i>	5.1 Plan Scope Management 5.6 Control Scope
	Ensure a transparent role division in terms of responsibility, accountability and authority throughout the project	(1)	Value Stream Map, A3, Visual Controls	5.1 Plan Scope Management
	Make project progress visible to everyone	(1)	<i>Jidoka, Kanban, Visual Controls, Andon, Daily Kaizen</i>	5.1 Plan Scope Management 5.6 Control Scope
<i>Pull</i>	Pull tasks and outputs based on project demand and eliminate what does not add value	(1)	Value Stream Map, <i>Kanban, JIT</i>	5.5 Validate Scope 5.6 Control Scope
<i>Perfection</i>	Use the organization's instituted standards, procedures and guidelines effectively	(1)	Standardization, PDCA Cycle, <i>5S, Kamishibai</i>	5.1 Plan Scope Management
	Effectively manage change requests	(1), (2) and (3)	PDCA, A3, Root Cause Analysis	5.6 Control Scope
<i>Respect for People</i>	Engage and sustain extensive stakeholder interactions	(1), (2) and (3)	TQM, <i>Obeya, Daily Kaizen, Hoshin Kanri</i>	5.1 Plan Scope Management
	(1) – clients' unstable priorities (2) – incomplete understanding of stakeholders' requirement (3) – inability of stakeholders to communicate their needs			

Table 3. Lean Project Management Framework – Scope Management

Lean Principle	Initiative	Pain Points	Tools and Techniques	PM Processes
<i>Value</i>	Identify, clarify and prioritize requirements early, often and proactively, including only what creates value	(1), (2) and (3)	A3, Obeya, Yamazumi Chart	5.2 Collect Requirements 5.3 Define Scope
<i>Value Stream</i>	Map the value stream and eliminate non-value-added elements	(1)	Value Stream Map, Yamazumi Chart	5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS
	Reduce the focus to a small subset of requirements, which are accurately defined	(2) and (3)	Heijunka, Value Stream Map, A3	5.3 Define Scope 5.4 Create WBS
	Define indicators and metrics to manage the project	(1)	Visual Controls, Andon, Poka-Yoke, Kamishibai, Daily Kaizen	5.1 Plan Scope Management 5.6 Control Scope
<i>Flow</i>	Promote collaborative and inclusive decision making to resolve the root cause of issues	(1), (2) and (3)	Obeya Room, PDCA, Root Cause Analysis	5.1 Plan Scope Management 5.6 Control Scope
	Ensure a transparent role division in terms of responsibility, accountability and authority throughout the project	(1)	Value Stream Map, A3, Visual Controls	5.1 Plan Scope Management
	Make project progress visible to everyone	(1)	Jidoka, Kanban, Visual Controls, Andon, Daily Kaizen	5.1 Plan Scope Management 5.6 Control Scope
<i>Pull</i>	Pull tasks and outputs based on project demand and eliminate what does not add value	(1)	Value Stream Map, Kanban, JIT	5.5 Validate Scope 5.6 Control Scope
<i>Perfection</i>	Use the organization's instituted standards, procedures and guidelines effectively	(1)	Standardization, PDCA Cycle, 5S, Kamishibai	5.1 Plan Scope Management
	Effectively manage change requests	(1), (2) and (3)	PDCA, A3, Root Cause Analysis	5.6 Control Scope
<i>Respect for People</i>	Engage and sustain extensive stakeholder interactions	(1), (2) and (3)	TQM, Obeya, Daily Kaizen, Hoshin Kanri	5.1 Plan Scope Management
	(1) – clients' unstable priorities (2) – incomplete understanding of stakeholders' requirement (3) – inability of stakeholders to communicate their needs			

Table 4. Lean Project Management - Procurement Management

Lean Principle	Initiative	Pain Points	Tools and Techniques	PM Processes
Value	Identify, describe and detail requirements in the Request For Proposal for the suppliers	(2)	A3, <i>Obeya</i> , <i>Yamazumi</i> Chart	12.2 Conduct Procurements
	Actively minimize the bureaucracy	(2)	<i>Kaizen</i> , Value Stream Map, <i>Jishuken</i>	12.1 Plan Procurement Management 12.2 Conduct Procurements
Value Stream	Develop a procurement management plan with assigned roles and responsibilities	(1) and (2)	Value Stream Map, A3, Visual Controls	12.1 Plan Procurement Management
	Work with suppliers to proactively identify and mitigate conflicts and risks	(1) and (2)	<i>Jishuken</i> , PDCA, <i>Kanban</i> , Supplier Involvement	12.2 Conduct Procurements 12.3 Control Procurements
Flow	Ensure a transparent role division in terms of responsibility, accountability and authority throughout the project	(2)	Value Stream Map, A3, Visual Controls	12.1 Plan Procurement Management
	Promote collaborative and inclusive decision making to resolve the root cause of issues	(1) and (2)	<i>Obeya</i> Room, PDCA, Root Cause Analysis	12.1 Plan Procurement Management 12.3 Control Procurements 12.4 Close Procurements
Pull	Interact with the suppliers during execution	(2)	Supplier Involvement, <i>Obeya</i> , Daily <i>Kaizen</i> , <i>Hoshin Kanri</i>	12.3 Control Procurements
Perfection	Use the organization's established standards, procedures and guidelines effectively	(1)	Standardization, PDCA Cycle, <i>5S</i> , <i>Kamishibai</i>	12.1 Plan Procurement Management
Respect for People	Promote close collaboration between internal customers and suppliers	(2)	Supplier Involvement, <i>Obeya</i> , Daily <i>Kaizen</i> , <i>Hoshin Kanri</i> , Team Work	12.1 Plan Procurement Management 12.3 Control Procurements
	(1) - bureaucracy (2) – waiting times			

Appendix D – Stage 2: Data Analysis of the Framework Validation Interviews

Organization A	Organization B	Organization C	Organization D	Organization E	Organization F	Organization G	Organization H
Question 1							
No.	Yes.	Yes.	Yes.	No.	Yes.	Yes.	Yes.
Very theoretical and condensed, requiring prior knowledge of the tools and techniques.	Easy to understand, but the lack of lean knowledge might turn it into an hard task.	The main difficulty might be related to the unfamiliarity with some of the lean tools.	How to apply the tools might be a challenge, because theory is always slightly different from practice.	Conditioned to prior knowledge of lean tools and principles.		Very clear and focused on the essential points.	
Question 2							
Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
	Suggests a dictionary to the application of the lean tools.	The organization major pain points arent in the Procurement. The framework should be expanded.	Suggests a dictionary to the application of the lean tools.	Approaches the pain points in the 3 areas, but the organization's pain points are in other areas, as well. The framework should be expanded.		The major pain points on these areas are approached.	In the HR Management, capacity should receive more focus.

Organization A	Organization B	Organization C	Organization D	Organization E	Organization F	Organization G	Organization H
Question 3							
No.	No.	Yes.	Yes.	Yes.	Yes.	No.	Yes.
The tools must be further detailed, describing in which situation (project or bottleneck) they should be used.	It depends on the organization's culture and the receptivity to new methods and tools.	The lack of lean culture in the organization might difficult the task.	It can be fully applied and seems to be a simple task.	It is required more detail on hot to practically implement the tools.	Suggests an instruction manual for the application of the tools.	It might be difficult to implement if the organization does not have PM and lean knowledge. It is essential to be validated and approved by the top management.	The application might be different considering the projects and the organization. Suggests a dictionary for the tools implementation.
Question 4							
Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.
	But the organization must be open to changes.	It makes all sense to join PM and Lean.	The framework is simple to understand and implement, adding value to the projects. It is in line with pain points and bottlenecks.	Recognises that PM might benefit from using lean tools and techniques, and also tools from other areas.	It does bring value, but it is necessary to measure the impact of the project's profit margin.	Clearly.	With a dictionary for the implementation of the lean tools, the framework might be seen as a guideline to solve bottlenecks.