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Portfolio Management of Research Projects in the Public and Private Sectors

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Preface

This thesis work is carried out at the department of Industrial Economics and Technology Management (IØT). It constitutes the final thesis for the Master of Science in Project Management and was carried out during the spring semester 2011 at the Norwegian University of Science and Technology (NTNU).

This thesis has been both a challenging and rewarding experience for me. Academically, I was able to specialize in a topic of great interest in the discipline of project management. Personally, I learned to deal effectively with complexity and uncertainties in projects in order to achieve my goals. I am very pleased to have had the opportunity to culminate my studies with such a great learning experience.

I would like to thank my supervisor Research Scientist Anandasivakumar Ekabaram, Siva, for his time and disposition to guide me through every aspect that surrounded my work. I greatly value his knowledge and personal reflections shared with me through our discussions; these are very much reflected throughout this thesis. Many thanks to my supervisor Associate Professor Tim Torvatn for his guidance which helped me set the focus and shape the approach of my thesis work. I also thank Professor Ole Jonny Klakegg for sharing with me his knowledge. His words emphasized the importance of the topic of this thesis and strengthen my interest in it. I highly value the collaboration of the interviewees; their contributions greatly enriched my work.

Finally, I would like to thank my parents and brother for their unconditional support during this, my latest journey. This (ad)venture has been possible because of you.

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Summary

The purpose of this thesis is to gain a broader understanding on how the process of portfolio management of research projects is done in practice in both the public and private sectors. To achieve this, information is gathered from interviews with representatives from one public and one private organization and document analysis from a second private organization. The analysis of both theoretical and practical information provides an overview and a deeper understanding of the process in these public and private settings.

This thesis is divided into seven sections. *Section one* consists of the introduction (Chapter One) and problem formulation (Chapter Two). The research model and research questions are presented. Furthermore, the importance and limitations of the thesis are described.

The *second section* sets the framework for the theoretical background (Chapter Three). This section presents basic definitions and background theory on relevant concepts associated with the main topic of the thesis. From this theory the models that will support the analysis and discussion are drawn and selected.

Section three introduces the methodology approach used for the research process. First, a general overview of the research process is presented. Then the selected methodology is introduced along with the tools that are used to assist this process. Finally, there is a description of the research instruments, interview and document analysis, used as well as an introduction to the interviewees and the nature of their organizations.

The *fourth section* consists of two chapters. Chapter Five presents the data gathered from the interviews and the document analysis. This section presents the information as was expressed by the interviewees and stated in the documents in order to introduce the factual data. Chapter Six includes the analysis and discussion of the data previously presented. In this chapter the interpreted information is separated in three categories and analysed according to the theory selected in the second section. A discussion of the main findings follows the analysis. Finally, a revision to the initial research model is illustrated.

The *fifth section* of the thesis winds up the research work with a conclusion on the topic. Here, the essence and reflection of the previous sections is presented. Finally, suggestions for future research are outlined.

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List of Abbreviations

P   Project

PM   Project Management

PMO   Project Management Organization

PMRP Portfolio Management of Research Projects

PPM   Project Portfolio Management

PRI   Public Research Institution

R&D   Research and Development

RP   Research Project

TO   Telecommunications Organization

1 Introduction

More and more, organizations rely on research projects in order to stay updated on new technologies, processes and practices on their fields. Through them, they remain ahead in the competition and sustain their competitive advantages. This is specially the case for organizations that are on the top of their industry and which other organizations follow closely to benchmark their strategic moves. This seems applicable for private organizations, however research and development also plays a big role in public organizations.

In the last few decades there has been an increased belief that organized research and development could stimulate economic growth and contribute to improving economic welfare. Given this, governments provide research and development (R&D) funding in order to promote scientific and technological development. With the increased need for production of scientific and technological knowledge in the public sector, there has been an increase in R&D activities performed by private organizations in order to match these production needs.

Whether they are of a public or private nature, organizations rely on projects as means to deliver results. This derives in the tendency to engage in several projects simultaneously. Organizations group these projects in portfolios which should be managed in order to decide its composition and strategic moves.

This managerial task is known as *Portfolio Management* which applied to R&D projects is defined as:

> "*a dynamic decision process, whereby a business's list of active new product (and R&D) projects is constantly updated and revised. In this process, new projects are evaluated, selected, and prioritized; existing projects may be accelerated, killed, or deprioritized,; and resources are allocated an reallocated to the active projects. The portfolio decision process is characterized by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects, and multiple decision-makers and locations*" (Cooper, Edgett, & Kleinschmidt, 2001)*.

The aim of the present thesis is to gain a better understanding on how this process is applied in both a public and a private setting. The thesis work focuses on the analysis of one public organization and two private organizations. While the sample may not be representative to completely understand the behaviour of organizations and their portfolio management, it provides an opportunity to model the process in these settings.

The project is lead through a series of iterative literature review supported by interviews and document analysis. The research questions represent the point of reference to start the research. This project is approached with an open mind, which allows re-evaluating the initial assumptions of the thesis and gives flexibility to the researcher. A more in-depth description of the methodology followed in this report can be found in the fourth chapter of this project.

The motivation behind this master thesis developed from previous studies on project management of research projects. During these studies a less known topic came up: portfolio management of research projects. It appeared that, while it was a less known topic, it was not of less importance. Through discussions with professionals from both research institutions and industrial organizations, it became evident the relevance of the topic. I was motivated by this relevancy which is present in both the public and private sectors.

2 Problem Formulation

This master thesis aims to present a description and comparison of the process of portfolio management of research projects undertaken in a public and a private organization. The major focus in this regard is to identify the commonalities and differences of the organizations' practices with respect to portfolio management and obtain a better understanding on how the process works in both organizations. This understanding and thesis will hopefully be helpful for organizations that seriously consider R&D and for researches who will work on this topic in the future.

There may be several research questions that can be studied in connection with portfolio management of research projects. I choose to consider some important research questions within the scope of this master thesis. The research questions are presented and explained below.

2.1 Research Questions

The focus of the investigation behind this project is based on the following questions:

- How do organizations perform the portfolio management process?
- How do organizations select which research projects should make up their company's project portfolio?
- How do public and private organizations define success in research projects? What drives the difference across firms, if any?

2.2 Research Model

The research model considered for this master thesis is the following:

Figure 1: Research model

The model is based on my assumption that organizational strategy plays a major role in the way an organization proceeds to lead the activities associated with managing its portfolio of research projects, which in turn have the main purpose of generating knowledge and possibly bring competitive advantages to the organization.

Based on this understanding the research approach, as will be explained in a later section, was developed in order to study to what extent the model reflects reality.

Though the terms strategy and knowledge are not explicitly mentioned in the research questions, both terms are underlying aspects that reflect on the research questions and hence this study. The research questions and research model are connected to each other and complement each other in such a way to highlight the topic this thesis.

2.3 Importance of Thesis

As part of a previous project for the Specialization Course of the Master in Project Management at NTNU, I got acquainted with the challenges and uncertainties associated with research projects. During the research phase and in discussions with interviewees from research institutions and industrial organizations, peers and professors it became evident that one area of interest in R&D for those developing in the R&D environment is the one related to portfolio management of such projects.

While portfolio management is an important topic in the literature of Project Management, there are fewer investigations that link this topic with specifically research projects. This may be because only recently the interest in research projects has been growing and this discipline is now seen as a potential tool for business success and competitive advantage.

It became clear that organizations rely more on projects as a means to deliver results. Organizations arrange projects in portfolios according to their goals and strategy. Research projects, which may be among the projects in the portfolio or be the sole elements of the portfolio as will be explained later, help organizations keep updated in new technologies, methodologies, processes, etc. However, in private organizations investing in Research projects, whether internally or externally obtained, may seem as an unnecessary expenditure given the focus on day to day processes. On the other hand, there are public

organizations specifically dedicated to generate or fund research projects in order to generate knowledge and development of public interest.

Either way, both private and public organizations that wish to remain competitive have a tendency to undertake research projects. The nature of both organizations may lead to different approaches on how to manage their portfolios. This could develop into managerial activities that while work on one setting may not be useful on the other and vice versa.

Getting to understand how these managerial activities are performed in the public and private settings can give future researchers and organizations interested in R&D projects an insight on some of the current practices in these settings.

2.4 Research Approach

Once the importance of the topic was clarified the topic was better delimited through literature review and brief discussions with academics and professionals knowledgeable in the area. Literature review includes basic theory of portfolio management, research projects, portfolio management of research projects. Furthermore I used theories on portfolio evaluation and selection and tools and techniques for portfolio management. This general literature provides a framework within which I could look at and describe portfolio management of research projects.

Portfolio management of research projects can be seen in two ways. One is when a company has a portfolio that includes all types of projects (IT, construction, R&D, etc.) and makes selection, resource allocation or termination decisions considering all of these projects. I will call this a *Mixed Project Portfolio* (Figure 2: Project portfolio), where Project (P) 1, 2... N, coexist with Research Project (RP) 1, 2... N.

Figure 2: Project portfolio consisting of mixed projects

The other way of looking at portfolio management of research projects can be when a company either undertakes only research projects or they simply manage them

independently of the projects which support day to day activities (IT, procurement, etc.) In this case, it is possible to talk about a *Portfolio of Research Projects* (Figure 3: Portfolio of research projects), in which activities of portfolio management are done only considering the interdependencies of research projects within the portfolio.

Figure 3: Portfolio of research projects

For purposes of this project, the focus is on this second way of looking at portfolio management, where the organizations' portfolio consists only of research projects; hence the context of this study.

This research study is based on an iterative process – a learning cycle – which helped refine the course of the study and further investigation. Based on this an interview guide was created; this interview represents the basis for the qualitative approach in this paper. The interview, as it will be explained later, is a semi-structured interview allowing the researcher to address the issue with an open mind as well as giving the opportunity to direct the interview in the desired direction or adding relevant topics. In addition to the interviews, document analysis is also used to support the topic. The analysis of the document is done adhering to the same premises and perspective of the interviews with the aim of finding important and relevant information.

This process helped create a framework within which it was possible to operate in a flexible manner. Through this, the research questions were refined and fine-tuned in order to emphasise the main elements of the research topic.

To complete the research, I present an analysis of the findings. Whenever comparisons are possible, they will be presented. Finally conclusions that resulted from the analysis will be drawn. Further information on the methodology followed for this project is explained in the following chapters.

2.5 Scope and Limitations

The major limitation associated with this project comes from the amount of time dedicated to the investigation. The project is developed during the spring semester of 2011 as a master thesis for the Project Management program. Due to this time limitation, the number of cases to be analysed will be limited to three organizations. Though the sample may not be representative to fully understand the behaviour of organizations and their portfolio management, it provides an opportunity to look at some kind of pattern in organizations' practices with respect to portfolio management of research projects. Furthermore, this thesis can be used as a base for further research in the matter; a stepping stone to go further.

In the cases where specific literature regarding research and development projects was hard to find or of no access, general literature on portfolio management and project management is used as a source to discuss relevant issues. The same applies to models and tools consulted on the matter. Regardless of these limitations, I believe that a better understanding on the topic will be possible through this study to reach conclusions and provide a base or reference for academics, practitioners as well as general public who are interested in the topic.

3   Theoretical Background

This chapter presents the theoretical background of the report. To begin with, the concepts associated with the main topic *Portfolio Management of Research Projects* (PMRP) are presented. The objective of this is to get acquainted with them, to have a better understanding of what is discussed by different authors and to choose specific definitions to work with. Once the main topics and definitions are introduced, three main concepts related to PMRP are presented. The first one is the influence of *Strategy* in PMRP and why organizations choose to rely on strategy to support it. The next section deals with the *Selection* process and presents some methods and criteria for project evaluation and selection suggested by the literature available. The third concept is project *Success,* which is explored from an overall project management perspective and more particularly from a public and private organization perspective. The concept of success is looked at in order to understand what organizations perceive as successful and how it impacts their business in future strategy, project selection and other areas.
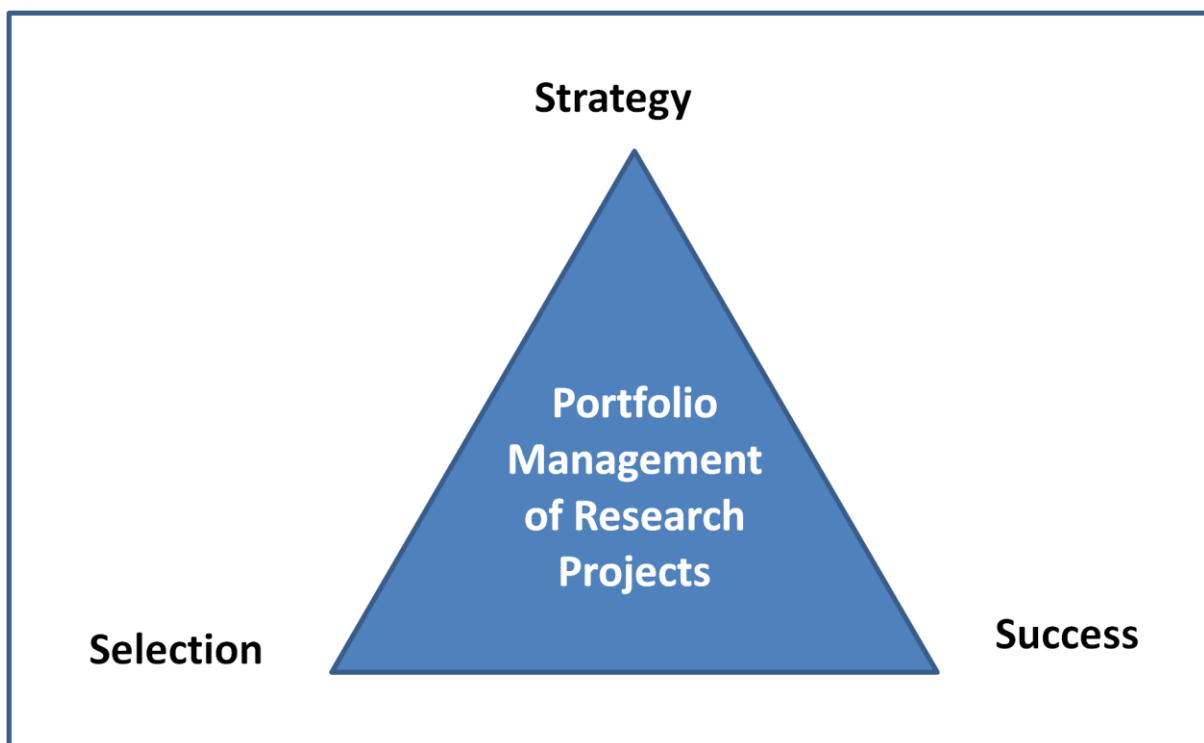

Figure 4: Theoretical framework

3.1 Basic concepts of the Portfolio Management of Research Projects

This section presents the definitions of the basic concepts associated with the report. First, I begin by briefly introducing the evolution of research and development projects and their nature. Next, the definition of portfolio management is presented. After these two presentations, other relevant topics are described. Finally the main topic of the research, portfolio management of Research projects, is introduced.

3.1.1 Research and Development Projects: a Private and Public Approach

David et al. (2000) present a very comprehensive analysis of the development of R&D research in the US. According to the authors the end of the 19th century marked the beginning of organized research and development activities upon the productive resources for societies. Since then, the percentage of national gross product directed by both private and public organizations towards increasing the scientific and technological knowledge has increased. The same study claims that during the 1930s, the

> *"total R&D expenditures in countries such as the US, the UK and Japan remained in the range between two-thirds and one-quarter of one percentage point of their respective national product figures."* (David, Hall, & Toole, 2000).

Since then there was an increased belief that organized research and development could stimulate economic growth and contribute to improving economic welfare, which led governments to create public institutions supporting civilian science and engineering. This gave way to an expansion of government agency research programs in non-defence as well as military technologies, and established models for the performance of government-funded R&D by private sector contractors.

With the increased need for public production of scientific and technological knowledge, there was an increase in R&D activities performed by private organizations in order to match this production needs. This is given that technology is the most crucial factor for the progress of a nation's economic development and living standards (Chang & Hsu, 1997). In order to promote scientific and technological development, governments provide R&D funding. As a result, support for selective development of specific industries is provided through direct, project-oriented subsidies. Government policy concentrates resources on

long-term R&D problems and on expensive basic research that could not be undertaken by industry.

Whether they are of a public or private nature, organizations rely on projects as means to deliver results; this tends organizations to engage in several projects at a time. The nature of these projects varies from marketing to IT, environmental issues, procurement, new product development and research and development (R&D). More and more, organizations rely on *research projects* (R&D, new product development, innovation) in order to stay updated on new technologies, processes and practices on their fields. This is how they remain ahead in the competition and sustain their competitive advantages. This is specially the case for organizations that are on the top of their industry and that influence other organizations to follow them closely to benchmark their strategic moves.

In order to maintain competitive advantage, organizations need to develop successful product and process innovation (Archer & Ghasemzadeh, 1999; Mikkola, 2001) for what they turn to R&D projects to achieve this. However R&D projects have a very particular nature. Research projects are characterized for being associated with a high degree of uncertainty and unpredictability (Balachandra, K, & Pearson, 1996). Therefore, large scale R&D projects require large budgets and high risk and long term programs (Chang & Hsu, 1997). This is mostly due to the fact that the outcome of a research project, such as knowledge generation, is intangible and hard to measure through standard project evaluation.

3.1.2 Portfolio Management

Given the importance of developing research projects, organizations are faced with the task of conforming portfolios of projects. For practical purposes, this report considers *project portfolio* as:

> "*a group of projects that are carried out under the sponsorship and /or management of a particular organization*" (Archer & Ghasemzadeh, 1999).

The task of selecting which projects should be a part of the company's project portfolio is an important activity in many organizations. It is presented in the following definition.

Portfolio Management is defined as the strategic choices, resource allocation, project selection and balance of the pool of projects available for organizations to undertake (Cooper, Edgett, & Kleinschmidt, 2001; Linton D. & Walsh T., 2002; Wang & Hwang, 2005). However this activity is not an easy one to do. Managers find challenges in deciding which projects to undertake, how to allocate resources to them through their whole life cycle and how to balance the portfolio once projects are completed or have to be terminated. *Project Portfolio Management* (PPM) is a critical task in company performance. Some key questions to be considered before deciding to do project portfolio management are known as "Five Ws and One H" (The Enterprise Portfolio Management Council, 2009):

- Who can use the PPM process? Everyone from Chief executives, heads of department, managers, supervisors, portfolio, project and program managers, to systems engineers.

- What should PPM be used for? To manage multiple projects, programs, assets, software applications, resource allocation, products.

- When should PPM be used? When there is more than one project or program or decisions must be taken when it comes to proposal ideas competing for a slot in the portfolio, whether projects or programs should go forward or terminated, resource allocation, strategic changes, mergers, acquisitions or joint ventures to mention some.

- Where is PPM used? In both profit and non-profit organizations, government agencies, universities, investment firms.

- Why should PPM be used? To ensure that projects and programs are aligned with strategies, goals and business objectives, to communicate project and program details, to manage projects and programs as a whole. PPM is a holistic, systems approach to business projects.

- How to decide whether to use PPM or not? Conversations and discussions between executives, managers, project and program managers and experts are encouraged in order to assess the situation and define the business case.

Authors like (Blichfeldt & Eskerod, 2007) have identified the main managerial activities related to PPM as follows:
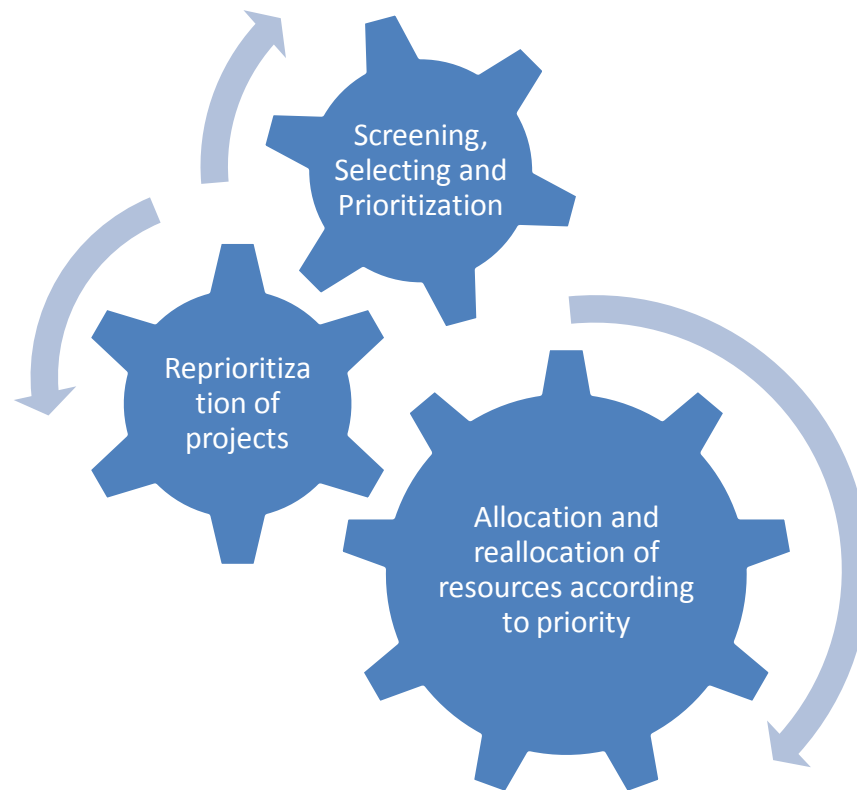
Figure 5 Managerial activities related to PPM, based on (Blichfeldt & Eskerod, 2007) p. 358.

Literature on PPM has widely focused on these managerial activities of project screening, selection, prioritization, balancing and resource allocation, while most recently focus has shifted to actual day to day management of the portfolio. Theories and literature have gone from focusing on tools, techniques and methods to a more managerial approach of how the activity is actually done. Thus, this thesis studies documented techniques and methods PPM, but keeps in sight the importance of the actual activities undertaken by the institutions.

3.1.3   Portfolio Management of Research Projects

Global market changes and the interest of business organizations to remain ahead of their industry, tend organizations to rethink their competitive strategy more often than before. Firms that cannot supply innovative products faster than competitor, lose competitiveness. R&D projects are used as a source of strategy, because they help target the increasing complexity demanded by shorter life cycles of products and services that wish to remain ahead and up to date (Mikkola, 2001). Most importantly, organizations have an increasing interest in evaluating their R&D projects from a portfolio's perspective; in which project selection, resource allocation and balancing remain the main activities to be performed.

According to McNally (2007), managing R&D is considered as one of the three core business processes.

Perhaps the most comprehensive definition of *Portfolio Management of Research Projects*, and the one to be considered for this thesis, is given by Cooper, et al. (2001). The authors describe the term as:

> "*a dynamic decision process, whereby a business's list of active new product (and R&D) projects is constantly updated and revised. In this process, new projects are evaluated, selected, and prioritized; existing projects may be accelerated, killed, or deprioritized,; and resources are allocated and reallocated to the active projects. The portfolio decision process is characterized by uncertain and changing information, dynamic opportunities, multiple goals and strategic considerations, interdependence among projects, and multiple decision-makers and locations.*"

This is an important and critical task to be undertaken because it requires a considerable amount of human resources and opportunity costs incurred as projects go from the selection phase to the implementation. At the same time this is a difficult task because decision makers have to work relatively fast with little reliable and highly changing information. Therefore the selection and development of successful innovations has a high degree of risk associated with it (Nesse & Velde, 2010).

In order to manage portfolios of research projects, organizations rely on different tools or techniques. Literature (Wang & Hwang, 2005) points that R&D portfolio decisions are hard to take given the nature of R&D projects and environment. On the one hand, R&D projects have long lead times, and on the other hand, market and technology are so dynamic that it makes information for portfolio management seem unavailable and unreliable. All organizations that wish to engage in R&D are faced with the problem of managing the portfolio of research projects, where projects have to fight for a limited pool of resources. At the same time project selection becomes a complicated task because the decision maker has to determine which new proposals should be funded, which existing projects should be continued and to what extent a resource should be involved in the selected project of the portfolio (Chien, 2002).

Therefore a set of methods have been developed to assist managers in this task. Authors divide these methods in different categories. For example Wang & Hwang (2005) state that there are mathematical, strategic and benefits measurement methods. Cooper, et al. (2001) divides them in more detail as into financial, probabilistic, options pricing, strategic, scoring models, analytical hierarchy, behavioural and mapping approaches. Linton et al. (2002) make a comparison of different methods proposed by other authors and they classify them into financial, strategic, quality, environment, market and technological approaches. While all the methods are of great interest, for purposes of simplification, this thesis divides the approaches to portfolio management of research projects into three categories:

- Strategic Management Tools: These tools are used to show the connection between research projects and organizational strategy. Examples of these are: bubble diagram, portfolio map, strategic bucket method, brain storming and SWOT analysis, to name a few

- Financial Measurement Tools: These are used to estimate the benefit of an R&D project. Examples of these are: *q*-sort, merit-cost value index, net present value (NPV).

- Mathematical Programming Models: These models pretend to optimize functions that are subject to constraints related to resources, technology and strategies. These models can be based on linear, nonlinear, integer, dynamic, goal and stochastic mathematical programming.

Of particular interest is the study carried out by Cooper & Edgett (Cooper, Edgett, & Kleinschmidt, 2001), who surveyed 250 U.S. companies to identify their portfolio management methods in new product development projects. The results of the survey reflected that even though financial methods are the most commonly used they yield the poorest performance results. On the other hand, strategic methods are the second most popular and they perform the best. Cooper and other authors (Archer & Ghasemzadeh, 1999) (Chien, 2002) (Wang & Hwang, 2005) agree that mathematical methods are the least popular since they are perceived to be too complex to understand and use. Literature suggests that the use of a mix of portfolio methods may yield better results. Therefore, authors have constantly tried to develop new models and methods in order to facilitate the management of R&D portfolios.

On the mathematical perspective there are several approaches or models proposed for the portfolio management of research projects. Some authors like (Fan, Chen, & Fukushima, 2007) have proposed a mixed model for portfolio selection based on the fuzzy decision theory. However this approach is aimed at investors who wish to allocate their wealth among traditional securities and R&D projects. By giving the research project a numerical value, it is levelled with the traditional investment and therefore a uniform evaluation can be produced. Along the same line of investment analysis, van Bekukum, Penings, & Smit, (2009) propose an approach where they attempt to prove that diversification while investing on R&D projects is the most effective way to deal with the risk associated with them.

The mentioned above authors conclude that the strategic approach is an appropriate way of managing portfolios of research projects. This is in line with what Chang & Hsu (1997) state; according to the authors R&D quality management depends on:

- Defining and understanding how to direct R&D activity toward producing expected benefits.
- Defining and understanding review and evaluation of roles and functions in the R&D process and
- Applying gained knowledge to improving overall R&D performance.

Improving the quality of R&D portfolio management will lead to greater R&D benefits and further improvement in overall R&D performance (Chang & Hsu, 1997). The notion of strategy is seen in this regard as an effective means to ensure the required quality and the intended benefits. Therefore there is an increasing importance of deeper research on the role of strategic alignment in the management of R&D portfolios. This issue is dealt with later in this chapter.

3.1.3.1 The relationship to Systemic Thinking

A brief introduction to theory of systemic thinking is worth mentioning when it comes to portfolio management of research projects. Some authors (Michael C, 2003; Senge, 1990) define a system as a complex whole whose functioning depends on the interactions of its parts. Michael (2003) states that systems can be studied from two different approaches: *holism* and, the more traditionally used alternative, *reductionism*. While the latter focuses

on the parts and attempts to understand them in order to understand the whole; the former sees the system as more than the sum of its parts. Holism, hence, sees the wholes as it is formed from the interactions between its parts. From this perspective it is the whole which gives meaning to the parts and their interactions.

In this project setting the system is considered to be the portfolio of research projects. Therefore, the functioning of the portfolio does not depend on the selection of individually good projects. This is, a collection of good projects do not necessarily conform a good portfolio. Why is this so? This is because from the holistic perspective the system, the portfolio, gives meaning to the individual parts, the projects. This means that the strategy, goals and direction of the portfolio dictates the nature of the projects that should be part of the portfolio, while at the same time the interactions between the individual project impacts the success of the portfolio.

The same concept applies to the rest of the tasks to be done in the management of the portfolio. Therefore, it is not possible to talk about good practices in portfolio management if the focus is on, for example, the resource allocation task, without considering its interaction with the other vital tasks of the process.

Systemic thinking and its linkage to this thesis will be further presented later in this report.

3.2   Strategic Alignment

As stated on the previous section, there are different methods on how project portfolios can be managed which are broadly grouped in strategic, mathematical and financial. Given the complexity of mathematical models and the shortcomings of the financial models, there is a tendency to rely on *strategic methods*. According to a study prepared by Linton D. & Walsh T. (2002), the application of economic based quantitative modelling methods to R&D projects present several major pitfalls. These pitfalls are based on the risk factor that comes with R&D projects. The expected economic outputs and required economic inputs are not clearly defined; therefore managers can only rely on the analysis of highly subjective judgments of economic process with considerable variances. This is even more challenging when different stages in the R&D life cycle are considered. The fact that the outcomes of R&D projects are hard to forecast and predict with accuracy means that the economic

outcome is a guess work hence coming with a high degree of risk (van Bekukum, Penings, & Smit, 2009).

Due to the challenges presented by economic and mathematical models, managers have tried to find new ways to perform research projects and reach competitive advantage through the realization of their organizational strategy. A *strategy* arises from focusing on key strategic processes and developing simple rules that shape those processes (Eisenhardt & Sull, 2001). The strategic vision has a function of directing the firm into a certain direction and motivates individuals to work towards achieving a shared goal (De Witt & Meyer, 2004); which in general refers to an organization's ability to remain ahead in its industry and sustain such competitive advantage.

Competitive advantage is the result of a thorough understanding of the external and internal forces that strongly affect the organization. Externally, a firm must recognize its relative industry attractiveness and trends, and the characteristics of the major competitors and government regulations. Internally, a firm must identify its competitive capabilities (Mikkola, 2001). It is important to note that this internal and external analysis, or SWOT: Strengths, Weaknesses, Opportunities and Threats, is taken at a specific point of time, so there is a possibility that it will be out-dated by the time the strategy is being implemented and results are considered. This is why it recommended that this type of analysis to be taken as an assessment of the current situation and most of all to be updated constantly (De Witt & Meyer, 2004).

Through this internal and external analysis, organizations are then able to shape the criteria against which projects should be evaluated in order to be selected and form the portfolio. One of the main dimensions that helps shape the portfolio criteria mentioned in literature (McNally, 2007) is the one of strategic direction. In this dimension managers try to assess projects in terms of how closely they reflect the organizational strategy. While other dimensions, such as value maximization (financial) or balance (proportion) are important, strategic direction seems to be highly related to R&D performance. Furthermore according to some authors (Cooper, Edgett, & Kleinschmidt, 2001; McNally, 2007) firms are not equally effective in the task of implementing this strategic dimension.

More and more literature emphasizes the importance of applying project portfolio management in line with the strategy (Nesse & Velde, 2010). Business strategy, according to Meskendahl (2001), describes the way in which a firm decides to compete in the market compared to its competitors. Project portfolio structuring requires this strategy to be considered as means of placing guidelines and restrictions for project selection. The importance of this lies in the main focus of choosing the right projects, meaning the projects that rightly reflect and support the organizational strategy; therefore showing the correlation between strategy, project portfolio management and business success (Meskendahl, 2010). The author suggests that through portfolio structuring and project portfolio success, strategic orientation has an effect on business success. A reviewed figure of his proposed model is presented as follows:

| Strategic Orientation | Project Portfolio Structuring | Project Portfolio Success | Business Success |
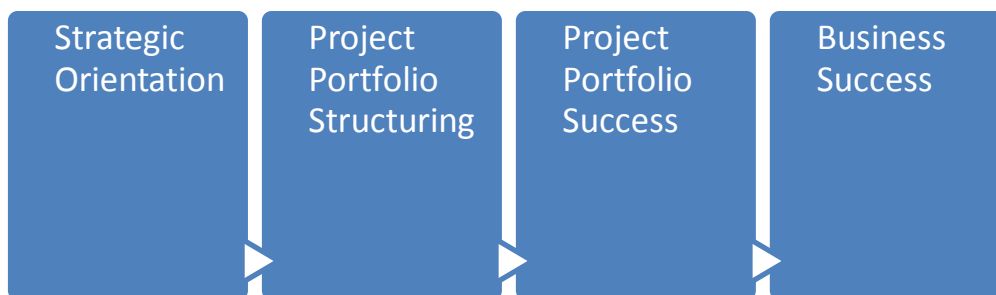
Figure 6: Adapted general framework (Meskendahl, 2010)

Other authors (Verma, Mishra, & Sinha, 2011) suggest that given the priority established by the research strategy, the dynamism of the environment and the projects' interdependencies, developing the right projects at the right time is a matter of serious concern. Moreover, decision makers should keep in mind that the combination of individually good projects not necessarily constitutes the optimal portfolio (Chien, 2002).

These authors support the previously presented theory of systems thinking. The portfolio is seen as a system which biggest challenge is to consider interrelationships among projects and other interdependencies. What theory in this section suggests is that the definition and implementation of a research strategy will, in turn, be the optimal reference point for such portfolio elaboration. A strategic alignment is, thus, considered as the start in the definition of adequate managerial tasks for the overall portfolio.

Furthermore, Cooper's study (2002) revealed that benchmark business stand out from the rest because they place less emphasis on financial methods and more on strategic approaches. Literature review shows that several authors agree that strategic orientation significantly influences project portfolio management, decisions and the structure of the portfolio. Once the organizational strategic understanding of research is established, organizations can base their guidelines for project evaluation and selection on it.

3.3 Project Evaluation and Selection

Project portfolio selection along with managing the selected projects are crucial activities in many organizations. Portfolio analysis of R&D projects involves the detailed evaluation of a selected set of projects in a firm. However, the case is common when companies have more projects to choose from than those that can be undertaken due to physical and financial constrains or scarce resources. Therefore companies look for guidelines and techniques to estimate, evaluate and choose project portfolios. Literature and research on the topic tries to identify which criteria are followed by managers and decision makers to achieve this. The criteria and dimensions that are used vary across firms. This is also the case for the formality of evaluation and selection processes (McNally, 2007). According to Chien (2002) the number or models for R&D project evaluation and selection grew exponentially in the 1950s and 1960s; however this trend reversed as of the mid-1970s.

As it has been stated before, many models and tools are not used due to the perceived difficulty from managers when it comes to their application and the difficulty of assigning deterministic weights to the variables associated with research projects. However, in literature there are plenty of tools that try to assist managers in this selection process from a different perspective.

One study of interest is the one made by (Archer & Ghasemzadeh, 1999) who propose a framework so that decision makers can choose from a variety of techniques or models. Archer, et al. (1999) states that the process of portfolio selection uses project evaluation and selection techniques in a progression of three phases: strategic considerations, individual project evaluation and portfolio selection. In summary, the first phase is supported by techniques that help to set a strategic focus and budget allocation; the second phase is used for individual project evaluation; the final phase includes project balancing,

project selection considering their interactions with other projects and other interdependencies. The main contribution of Archer, et al. is a framework that instead of rejecting models based on their nature (mathematical, financial or strategic), allows managers to choose a different model for each phase of the portfolio selection process.

The importance of this model is that it is a tool not to select and stick to a specific selection method, but it allows the utilization of several methods according to the phase of the process. This may require for managers who apply this model to have a broader and deeper understanding of the process, a systemic understanding, where a selection method is not seen as a unique standalone tool but as part of a bigger system. Given that different methods can be applied in different phases, the manager should understand the selection process and the methods, how they work and how they interact with each other and their dynamics. This way of thinking is supported by systems theory where no method, process or project can be seen as an island but it should be seen as part of a bigger entity and from whose interactions in the different gates should be understood (Michael C, 2003).
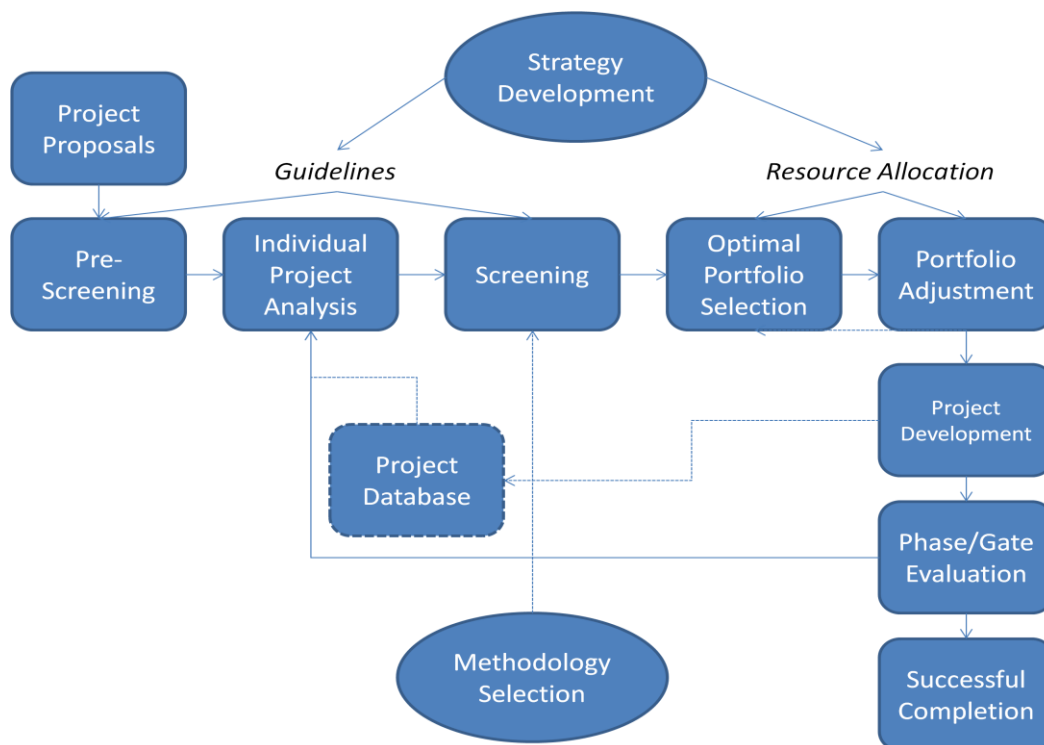
The model can be seen as follows:

Figure 7: Framework for project portfolio selection (Archer & Ghasemzadeh, 1999)

Another area of study in the portfolio management topic is the one that supports the use of strategy as the only means to set the guidelines for project evaluation and selection (Mikkola, 2001). According to these studies, the evaluation and election of products and projects in a portfolio should be made carefully so that they are in line with overall corporate strategy. It should force management to emphasize the importance of long-term perspective. One of the most important factors in analysing a portfolio or R&D projects is the ability to link competitive advantages of a firm to perceived customer needs.

In Mikkola, (2001) a comprehensive framework is introduced in which four elements of individual projects are evaluated: technological competitive strength, technology maturity, competitive impact of technologies and R&D project attractiveness. The shortcomings of this framework is that identifying the success factors of an innovation is not an easy task given that each industry faces different challenges according to the competitive structure of their market. Therefore, portfolio techniques would only serve to face challenges relevant for the R&D management of each unique organization.

In general, existing R&D project evalaution and selection models have challenges, because they

- often fail to consider interrelationships among projects,

- are unable to handle non-monetary aspects,

- fail to include the experience of the R&D manager and,

- as stated before, are simply perceived as difficult to understand and use (Chien, 2002).

The previously stated author proposes an approach for the evaluation and selection of R&D projects based on the selection of individual projects from a portfolio perspective as opposed of the selection of individually good projects which later should be fitted to the portfolio. Once more, it is possible to identify a relation to systems thinking and its application in the project selection process. Evaluating individual projects for selection from a portfolio perspective suggests system thinking as seen in a previous section. Based on Chien's perspective, a three layer model for project selection can be constructed:
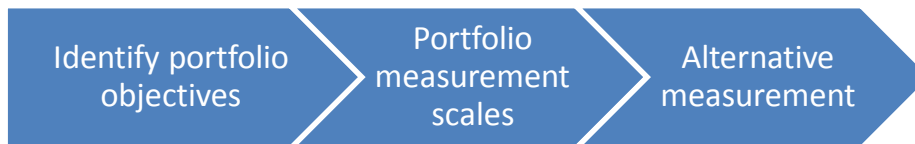
Figure 8: Phases of portfolio project selection, based on (Chien, 2002)

First, the portfolio objectives must be identified considering alternate attributes and selecting the ones that comply with such objectives; next, scales for measuring those attributes should be put in place; finally, the measurement of the different alternative portfolios is done by aggregating the portfolio attributes or objectives.

In general, most authors have presented a model to assist project evaluation and selection. There is an understanding that there is a gap between theoretical development and empirical application, therefore selection approaches should be able to serve as mechanisms to ask questions, collecting information, share opinions and facilitate communication (Chien, 2002). Overall, literature review shows the positive relation between portfolio selection and project portfolio performance (Meskendahl, 2010; Cooper, Edgett, & Kleinschmidt, 2001; Chien, 2002). This emphasizes the importance of project selection in portfolio management.

One last selection strategy worth mentioning is the one associated with the manager's dispositional traits (McNally, 2007). According to McNally (2007), manager's characteristics such as analytic cognitive style, ambiguity tolerance and leadership are related to certain portfolio management of research projects dimensions such as ability to choose the most important evaluative criteria when information is unclear. The conclusions of the author state that those characteristic affect the criteria as follows:

Personality trait	Impact on dimension of Research Portfolio Management
• Analytic cognitive style	• Ability to choose the most important evaluative criteria when information is unclear
• Ambiguity tolerance	• Reaching a strategic fit by taking a long term perspective of market
• Leadership style	• Weight given to each evaluative dimension

Table 1: Manager's personality traits and their influence over the dimensions of PMRP (McNally, 2007)

Based on this, the personality of the manager which feeds from his personal experiences is considered to have an impact on the portfolio management of research projects process. It is of interest to consider this perspective because social and personal characteristics cannot be completely separated from the selection process. While well-defined and previously established guidelines and methods are useful tools for project evaluation and selection, it is undeniable that such methods will be applied by people. Therefore, the personality and experience of the manager along with the selection tools, act as a complement of high importance for the appropriate management of the portfolio.

3.4   Project Success

This section presents the basics related to project success in an R&D setting. The underlining assumption is that project success can be ensured by controlling and evaluating the progress of the project. The objective is to have a better understanding on what organizations perceive as success and why this is important for portfolio management. In order to achieve this, first I will present a general overview of project success as general project management literature presents it. Then a comparison between public and private organizations regarding the perception of success of research projects will be done as means of presenting the main findings of literature research on the matter.

3.4.1   Success in Projects

General project management literature states that evaluating whether a project is successful or not depends on the perspective of the stakeholder to whom success is relevant (Samset, 2003). Two major topics come up when talking about project success: success factors and success criteria. Success factors are those factors with greatest influence in project success; in essence they are activities that must be performed in an appropriate manner in order to achieve the project's objective or goals. Success criteria is the criteria that measures whether or not the project has been a success.

Early project management literature based project success on the widely known triangle of cost, time and quality which illustrates the three primary forces in a project. Time stands for the duration of a project (dependent on factors like the number of people working on the project and their experience), cost for the budget and resources available (measuring the limited resources available to complete the project), and quality represents the demanded

requirements from the customer's perspective (linked to both cost and time, since a demand for a high quality results in higher costs and can also lead to a longer duration). However, more recent studies on project success state that project success cannot be associated only to these three concepts and propose a wider approach to success evaluation.

In this matter the study by (Samset, 2003) is of interest to this project. The author proposes a holistic view on project success, based on the idea that the success perspective changes over time.
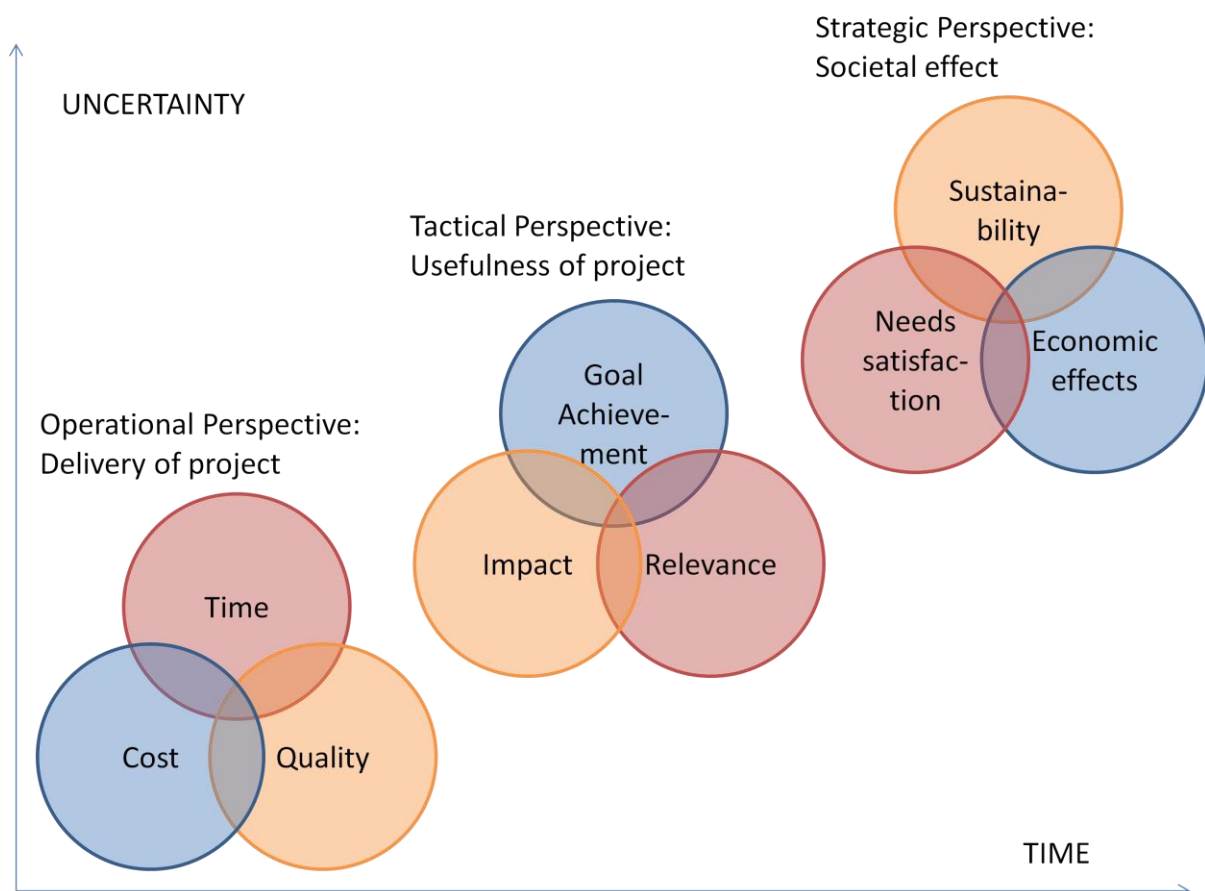
Figure 9: Different measures of success in three different perspectives (Samset, 2003)

Within this perspective project success can be measured on immediate, medium and long term time frames. The immediate results obey an *Operational* perspective measured at the moment of project delivery. This perspective deals with the previously stated terms of time, cost and quality. The medium term perspective, or *Tactical*, is related to the usefulness of the project. From this perspective the impact, relevance and goal achievement of the

project are more important. On the long term, success takes a *Strategic* perspective based on the effect that the project has had on the society; success is measured in terms of sustainability of the project, economic effects and needs satisfaction. As the perspective of project success evolves in time, so does its uncertainty; this one increasing thus making success harder to predict and achieve. This figure can also be seen particularly in connection with research projects, their success over time and emerging uncertainty associated with them.

Whether it is on the short, medium or long term, organizations are concerned with project success. As stated before, projects are used as means of implementing organizational strategy and achieving business success. Some authors have positively linked project success to productivity and therefore organizational growth (Chien, 2002; Meskendahl, 2010).

Some authors (David, Hall, & Toole, 2000), claim that the productivity growth effects of R&D seem to be positive and of relatively high rate of return at both private and public sectors. However, intended success of a project can be dependent on the nature of the organization who is undertaking it. A very good example is presented in Ishibashi & Matsumura (2006). The authors recall the Human Genome Project started by the US government which was later emulated by the private company Celera Genomics. The purpose of the Human Genome Project was to make information public and to improve worldwide welfare in the future through open use of information, rather than making profits. On the other hand, Celera Genomics had profit generation as its main purpose. Therefore project success for both organizations would depend on different outcomes and different purposes of the research project. This difference in perspective will be analysed further in the following section.

3.4.2   Private vs. Public Perspective

From literature review concerning the purpose of R&D projects in private and public organizations, it can be concluded that success on each sector is perceived differently depending on the outcome of the project. While on the private side organizations aim to achieve business success from a competitive point of view; pubic organizations aim at producing welfare and increasing life standards:
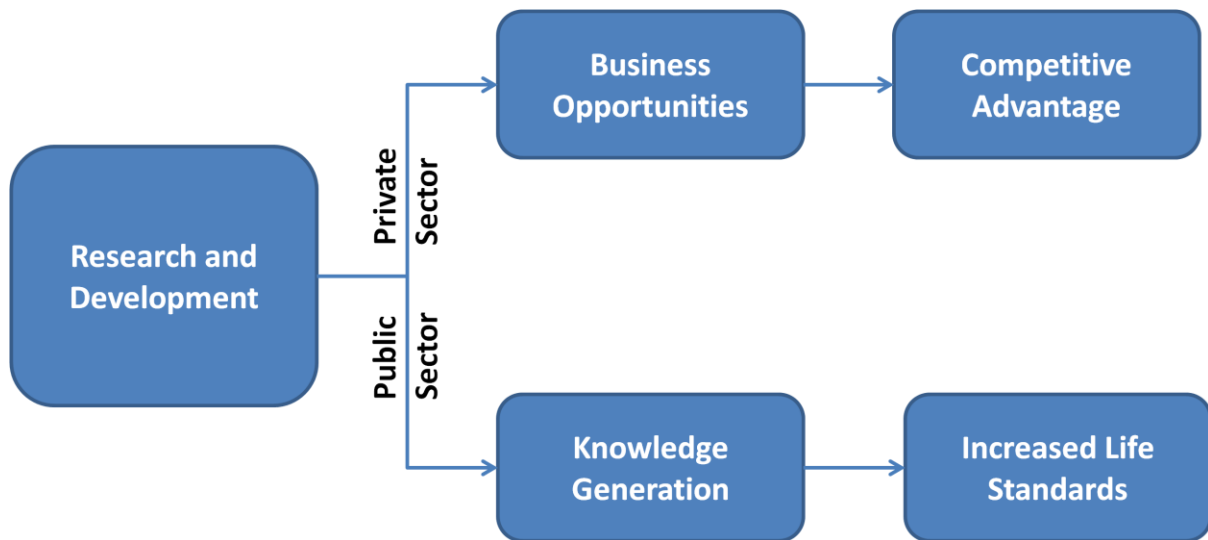
Figure 10: Public vs. private approach to R&D success

From a *private perspective*, organizations mainly label a research project as successful in terms of its ability to identify business opportunities which lead to competitive advantage and finally to profitability of the knowledge developed. In regards of R&D, authors (Ishibashi & Matsumura, 2006) classify private organizations as 'profit-maximizing' seekers. In this sense private organizations choose their balance between innovation size and R&D expenditure depending on the project's ability to produce profit.

On the other side, the *public perspective,* public research institutes choose their balance between innovation size and R&D expenditure depending on the project's ability to produce welfare and do not consider much on the effects that this decision has over private sector. In regards of R&D, the authors (Ishibashi & Matsumura, 2006) classify public research institutes as 'welfare-maximizing' seekers.

A good example to support the public perspective is the one presented in the study done by Chang & Hsu (1997). The paper studies the process used to support R&D research by the Taiwanese government whose main objective is to contact research institutions in order to develop technology for commercial application in the industrial sector. The Taiwanese Minister of Economic Affairs (MOEA), thus, forms a loop of the following four phases: identifying the industry needs and requirements; planning the technology to be developed; performing R&D activities; and diffusion of the technology to the industrial sector.
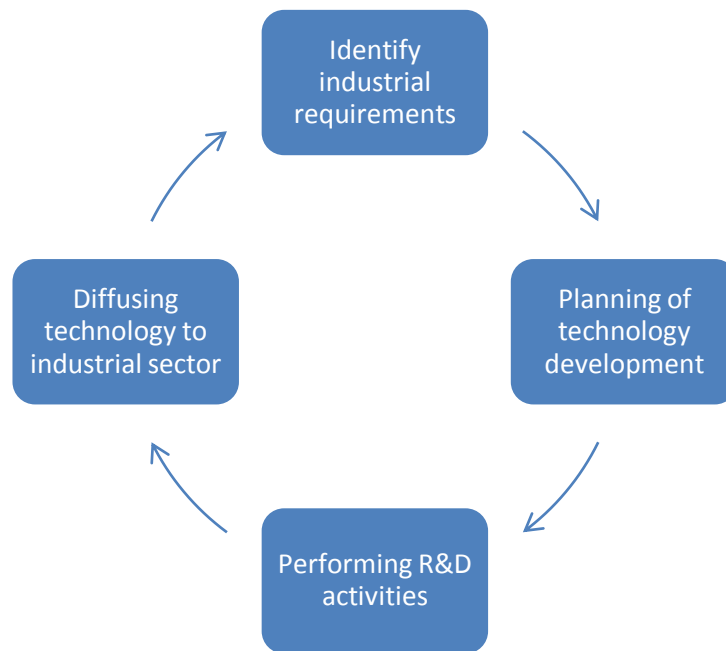
Figure 11: Taiwanese R&D project loop, based on (Chang & Hsu, 1997)

The Taiwanese government invested, for example, NT$11.6 billion in R&D grants for 13 non-profit research institutes (Chang & Hsu, 1997) in 1994. Project success in terms of benefits of this investment is summarized in the following table:

Direct Returns	Subsidiary benefits
• Steadily increasing flow of new and enhanced technological capabilities for domestic producers • Registration of patents and copyrights • Publication of research papers and reports in prestigious scientific journals around the world	• Direct technology transfers to the private sector • Technical education and service programs, seminars and symposia • Other competitiveness-stimulating delivery mechanisms

Table 2: Benefits of R&D investment in the Taiwanese government (Chang & Hsu, 1997)

Generally speaking, R&D performance is assessed by evaluating the level and extent of R&D activities – the experimental processes that scientists and engineers employ –and the results of the R&D activity, which include patents, publications, papers and technical reports. While Figure 11 seems interesting, I reflect upon a question whether this model is applicable for all countries. Managerial activities, including managing research projects, are influenced by national cultures, at least to a certain degree (Hofstede, 1993).

3.5   Summary and Model

Chapter 3 presents the literature review of the main topics associated with this master thesis. While the main topic of Portfolio Management of Research Projects may have many more subjects associated with it, I have chosen those which I believe to be of more impact to my research. It should be noted that while a fairly new topic, interest in PMRP is growing fast and more authors arise with an investigation on the matter. Therefore, the literature presented here may not be fully exhaustive, however it was the basis for this report and as comprehensive as possible.

In section 3.1 the introduction of the concept of Portfolio Management of Research Projects is presented along with various topics related to it identified in literature review such as project screening, selection, prioritization, balancing and resource allocation. While these are all areas of portfolio management of interest, for practical purposes the focus of this thesis regarding these areas is on the project selection which includes guidelines definition and definition of the research strategy as well as project selection.

Furthermore, it is mentioned in the same section that portfolio management of research projects has many different methods for project evaluation which could be divided in three main categories: Strategic, Financial and Mathematical. After literature review on the matter, the strategic methods seem to be most relevant to this project and reasons for choosing this method are given. Finally, a brief introduction to systems theory is presented along with its relationship to and impact on portfolio management.

Section 3.2 presents evidence of the relationship between strategic orientation and project portfolio success (Figure 6: Adapted general framework (Meskendahl, 2010)). This section stressed the importance given by some authors that the combination of individually good projects does not necessarily constitute the optimal portfolio; therefore, the implementation of a research strategy as a means for project selection is a viable option for decision makers. Moreover, through theory on systems thinking, strategy was defined as a good starting point to establish the general focus needed by systems such as portfolios.

The previous section gives way to and is complemented with section 3.3 where a more detailed description of some of the proposed selection process is presented. Chien (2002) identified that challenges in existing R&D project selection models and proposed an

approach (Figure 8: Phases of portfolio project selection, based on Chien (2002)) which became the basic model for the evaluation and selection section of this thesis.

Finally section 3.4 aims to provide a vision of how different or similar success in R&D projects is perceived from both a public and private perspective. The model proposed by Samset (2003), (Figure 9: Different measures of success in three different perspectives) thus became the basic model considered in this thesis for project success. Furthermore, the report by Ishibashi & Marsumura (2006), which defined private organizations as *profit maximizing* seekers and public organizations as *welfare maximizing* seekers, is the underlining understanding that will be used as a means of comparison for these sectors. This comparison is supported the model proposed in Figure 10: Public vs. private approach to R&D success.

The above mentioned theory and models, thus, constitute the essence of the theory chosen in this thesis and reinforce the initial theory model by stressing the influence of the research strategy over the project selection and success. The chosen theory also suggests a possible cycle where, driven by strategy, the selection of appropriate projects may lead to success. Success, in turn, helps reshape the research strategy. The reviewed model is shown next.
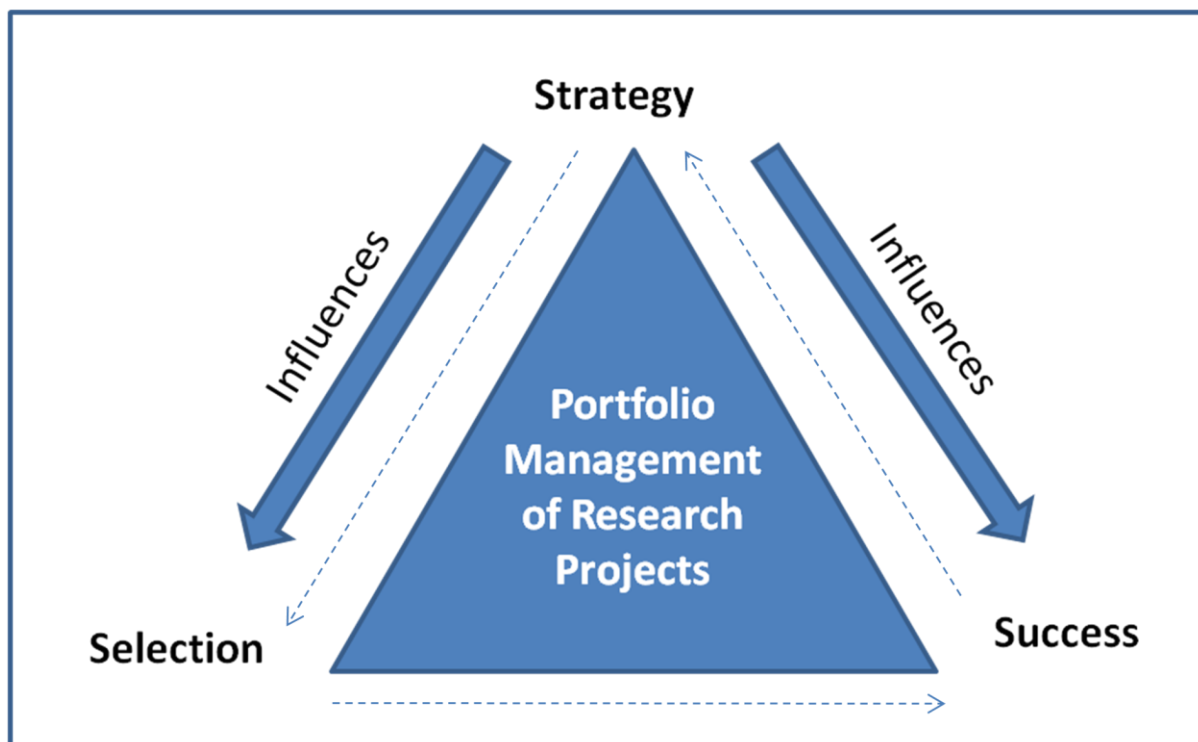

Figure 12: Reviewed theoretical framework

4   Methodology

This chapter presents the methodology used in this research project. First, a background on the research process that this thesis wok followed and its theoretical background are presented. Then, I present a background on the nature of quantitative and qualitative research; the latter being the method applied in this thesis. Next, the approach and method used for this thesis is explained along with its strengths and pitfalls. Also the theoretical model used for the interview is presented and explained. Finally, a brief introduction to the interviewees and their industries is given to have a general background of the context of the study.

4.1   The Research Process

Marshall and Rossman define *research* as a series of systematic strategies where the researcher gathers information about actions and interactions, reflects on their meaning, arrives at and evaluates conclusions, and eventually puts forward and interpretation, most frequently in written form. Real research is often confusing, messy, intensely frustrating, and fundamentally nonlinear (Marshall & Rossman). According to the authors, typically the researcher begins with interesting, curious or anomalous phenomena that he or she observes, discovers or stumbles across. The objective of performing research is to gain a better understanding of the problem or dilemma faced by the researcher and sometimes even to take action according to this understanding.

Agreeing with the previous authors, McGrath (1982) suggests that the *research process* can be considered as

> '*a series of ordered – though chronologically chaotic – choices.*'

The author states that even though those choices have a logical direction, they are also systematically circular. By this he means that while planning goes before execution or data collection before data analysis, the process starts from and goes back to a problem. However, rather than a closed circle, the process should be considered as a series of spirals; see Figure 13: The cycle of empirical research .

Questions about
the real world

Problem

Conclusions
about the real
world

Design

Relations

Operational
Plan

Variables

Observations
of the real
world

Data
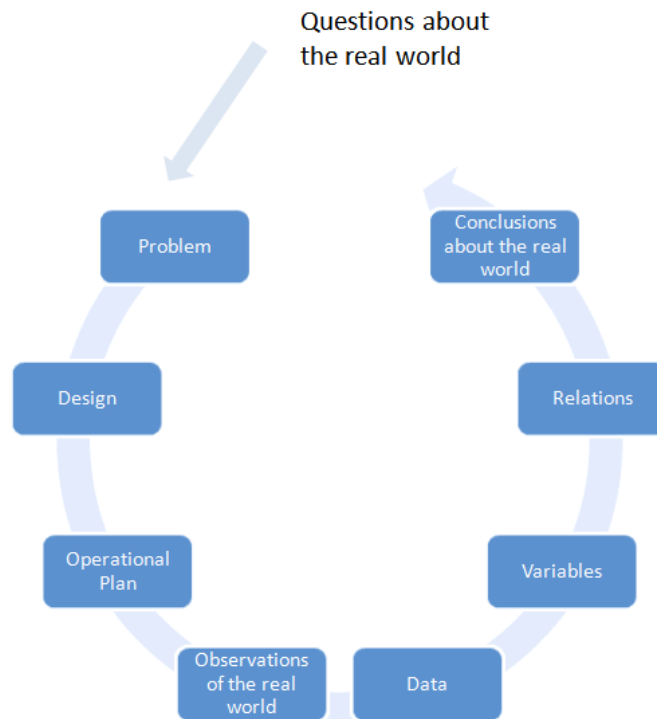
Figure 13: The cycle of empirical research (McGrath, 1982).

This model (Figure 13) is of particular interest to this project given that it reflects to a large degree the process followed in this research. First, a problem (research questions) is formulated. Then a plan research is designed and executed. In this step, which will be explained further in the next section, the real world is studied through interview and document analysis. Finally, after the data is collected, the analysis and interpretation of the results is presented. Moreover, it is expected that the results and conclusions about the real world will serve as a base for future research, giving way to a new problem definition just as stated in the model of Figure 13.

4.2   Qualitative vs. Quantitative Research

Generally qualitative and quantitative researches are seen as opposites and sometimes even contradicting research methods. However, according to some authors they should be seen as merely different ends of the same dimension,

> "*an informational continuum that runs from the numerical and purely quantitative to the highly descriptive and linguistic, with various levels in between*" (McQueen & Knussen, 2002).

According to the authors, there are many instances in which it is perfectly acceptable to use both approaches and even a combination of them. For purposes of this thesis, I have chosen to use the qualitative approach. However, before going further into explanations about the approach of this report, this section presents a brief introduction to both research methods as means to have a general background on the topic.

4.2.1   Quantitative Research

According to *quantitative research* everything in the social world can be described according to some kind of numerical system, for example, a person's sex can be represented by the number 1 for male or 2 for female. This method relies on the belief that only by adopting such a rigorous approach and by reducing all aspects of our universe to a common numerical system can true precision be achieved (McQueen & Knussen, 2002).

Through this numerical system the social world can be exhaustively analyzed with statistic techniques. Furthermore, the analysis can be presented in accordance to universal conventions that are familiar to other researches, students, scientist or policy makers. Some quantitative research tools are: surveys experimentation, field experiments, quasi-experimentation and questionnaire.

4.2.2   Qualitative Research

On the other side of the spectrum is *qualitative research* which according to McQueen and Knussen (2002) has its roots in anthropology, interpretivism and psychoanalysis. Qualitative research is both philosophy and a procedural approach; it is sometimes seen as a reaction against numerically based experimentalism since it is not primarily concerned with numbers. However, they have attempted to explore and describe, explain and predict.

According to Marshall and Rossman in qualitative design, the researcher has to initially decide among possible research questions, frameworks, approaches, sites, and data collection methods. After considering all these elements, the researcher must develop a research proposal. Building the research proposal demands that the researcher consider all elements of the proposal at the same time. This is a recursive process that is complex and intellectually challenging because the researcher needs to consider multiple elements of the proposal simultaneously. Some tools which support the qualitative research are: diaries, observation, interviews and case studies.

4.3 Approach and Method Used

This master thesis follows a qualitative research approach to present the project proposal and shape the present investigation. The project intends to have a mix of methods to gather data depending on the findings of the initial literature review. Literature review of portfolio management of research projects and related topics such as new product development and innovation are the basis for the project.

Based on this initial understanding, a semi-structured interview is developed. This type of interview, semi-structured with open questions, allows flexibility during the interviewing process and benefit from the richness of descriptive information. It is possible to dig further in a topic that may be interesting during a specific interview, change the course of the interview to cover relevant concepts and allow the interviewee to freely express ideas. At the same time, the interview provides a structure or general backbone useful to regain focus on the main topic and follow a pre-established path when necessary. The interview is be applied to managers knowledgeable and involved in the process of portfolio selection of research projects for their respective institutions. As a complementary method, document analysis is used to support the research of the topic. This document analysis is done in connection with a private institution. More information about this will be explained later on this document.

The data gathered develops into an assessment of the situation and is the basis for comparison against literature. From this assessment the findings are listed and discussed, conclusions are drawn and interesting areas of further research are suggested.

4.4 Interview

As stated before in this document, one of the main tools used for information retrieval in this project is a semi-structured interview. In this section the interview is presented; first general information about the interview and second an introduction to the interviewees and their background.

4.4.1 General Information and Limitations

The interview will be conducted with three interviewees. All of the interviewees are either managers or fairly knowledgeable and related to the process of project selection and management of their institutions. The number of interviews applied is limited, and it is

possible to say that they alone are not enough to completely model reality of the process. Another possible limitation is how the interviewees view the reality. Their understanding is subjective and based on their experience and background. This is a general limitation in connection with research methods (Ekambaram, 2008). However, the focus of the interview, along with the experience of the interviewees will be useful to have a better understanding of the practicality of portfolio management in institutions that make use of research projects. Data gathered and the analysis presented may be a good starting point for further research and reference point for people interested in the topic.

4.4.2 Interview Guide

The reason of the interview being developed as a semi-structured one is to be able to adjust and aim the interview questions according to the answers given in real time in order to make it easier and possible to obtain the desired responses from the interviewees and to allow, both them and the author, flexibility of questioning and responding. The interview guide can be found in the appendix of the present project (Appendix 1).

The interview guide was developed based on the following model of the process of portfolio management (It should be noted that the tasks highlighted in green are the focus areas of the interview):
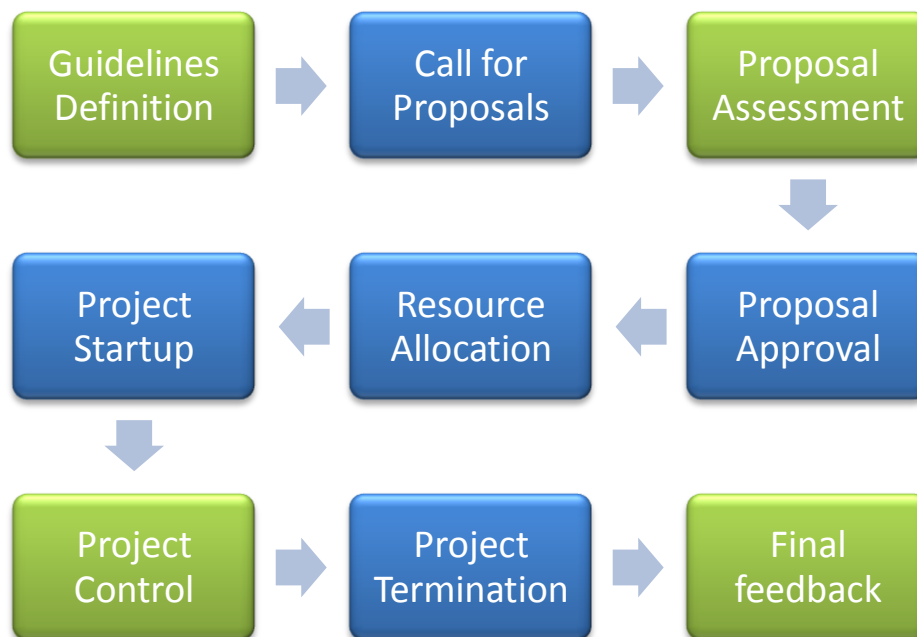

Figure 14: PMRP process, base model for interview

The previous model was developed after extensive literature review on the basic tasks to be undertaken while doing portfolio management. The process goes from the initial guideline definition of project focus to the final feedback after project termination. The limitation and focus of the project is on the four corners of the process. This is due to the fact that in these processes there are concentrated the majority of decisions and relevant tasks to be performed by the managers and decision makers.

These processes are better explained as follows:

- Guidelines Definition: This is the initial phase of the process where the decision makers decide the focus and strategy to follow regarding their research needs and goals. The main goal in this section will be to identify which criteria are used when defining the guidelines, how these are defined and which factors affect their definition.

- Proposal Assessment: In this phase the projects proposals are evaluated and selected according to specific guidelines based on the main guidelines shaped by the research strategy. The aim here is to identify the factors affecting the guideline definition and to have a better understanding on how the selection process takes place.

- Project Control: This phase is related to the control measurements or mechanisms applied on the research projects in order to keep them in line, focused and possibly even terminated. The goal is to understand the control mechanisms applied and the challenges associated with them on both private and public organizations.

- Final Feedback: The final phase of the process before the cycle begins again. The objective here is to learn how project success is measured when the project comes to an end and to identify means on how the final results are transmitted to the decision makers.

4.4.3 Introduction to Interviewees

As means of developing a better understanding of the applied process of portfolio management of research projects, three interviews were conducted between managers of both public and private organizations which currently undertake research projects. A brief

background on both the interviewees and the organizations they work for is presented in this section.

The *public* side is represented by two interviewees from a Norwegian Public Research Institution (PRI from now on). The PRI is the national authority on research funding in Norway. Its main goal is to fund and encourage scientific and knowledge related development that will have a positive impact on the nation's and the international welfare and sustainable development.

The PRI carries out the country's research strategy in order to increase the knowledge base, encourage international cooperation and meet the research needs of the society. The institution, besides being a research strategy implementer, is an advisor to the research policy priorities and a meeting place for researches, funders and end users of the research findings.

It is important to clarify that the PRI does not perform research projects itself. The PRI funds other institutions (private organizations, research centres, universities and particulars) so that they can perform the actual research. The PRI does perform the other activities of PMRP (research prioritization, such as project evaluation and selection, resource allocation, etc.) other than the actual research. According to this, when it is stated that the PRI 'undertakes' or 'performs' research projects it should be understood as it having research projects as the centre of the activities it performs.

Interviewee A is a Senior Advisor for the division of Science at the PRI. He is specifically involved with the area that deals with funding for independent research projects and has a two year experience in this position. *Interviewee B* has been the programme coordinator of one of the seven largest research programs of the PRI for the last seven years.

The *private* side was represented by two managers; one from a leading Project Management organization (PMO from now on) in the Nordic countries and the other one from the leading telecommunications organization in Norway (TO from now on). Interviewee C worked for eight years as an R&D manager at the PMO responsible for research projects and the contact person for customers buying research projects from the company.

The PMO is the leading company in the area of project management consultancy in the Nordic area. It has 320 employees and a turnover of 400 million NOK. It specialises in consulting of any kind of projects form which building projects represent the 60-70% of the volume and the rest comprehend health care services, public infrastructure projects, IT/technology projects and research projects which are given a big importance since they help the company differ from other standard project management companies. He focused the project-process related answers to a project related to buying research for the Norwegian Ministry of Finance.

Interviewee D, from the TO, works at a Telecommunications Organization. He is a researcher at the Research and Development department of the TO. In the early 1990s the TO implemented a stage-gate process for service development which allowed individual development projects to have a more unique approach from the idea to the launch phases. This also made that individual projects could have a more formalized and clearer organization in relation to the project and control groups; however, the human resources where spread over too many projects. This made effective development difficult to achieve along with the introduction of new development projects. By mid 1990s the TO introduced IT management service processes to manage the portfolio of development projects.

The Telecommunications Organization managed to reduce by half the development time from idea-to-launch of its research and innovation projects after implementing the systematic processes for portfolio management of R&D projects.

4.5   Document Analysis

Due to time constraints and other occupations, it was not possible to interview the fourth person who represents the private TO. Given this the interviewee got acquainted with the interview guide and the aim of the research and suggested some documents that could be studied which covered the main inputs of the interview. Therefore, document analysis became a complementary method for the research methodology.

4.6   Summary

This chapter presented the methodology used for this research project. First some basic theory on methodology methods was presented in order to have a broader understanding of the available methodologies. Next, the selected methodology for this paper was

presented which is semi structured interview and document analysis. The semi structured interview allows flexibility to adjust the interview during its development or even change the course of the interview as desired. The document analysis was introduced in order to add information of a public organization relevant to this report and complements the method used for this report. While the sample of interviewees is limited, the report is expected to shed light on the practical process of project portfolio management in an R&D setting.

5 Data Gathering

As stated before the methodology for data gathering includes both interview and document analysis. The interviews were conducted in a semi-structured way allowing flexibility to discuss further on topics of relevance and manage a natural flow of the interview as desired. This section presents the results of the interviews as a summary of what the interviewees replied to each of the sections in the interview. For each section, first the public side of the investigation will be presented followed by the private side. The private perspective will be formed by the interview with the representative of the Project Management Organization and complemented, when possible, with the data from the analysis of the document provided by the representative of the Telecommunications Organization.

The information presented in this section will therefore become the starting point for the analysis, interpretation and further discussion of relevant topics.

5.1 Strategic Guidelines

The first part of the interview deals with the strategic guidelines that the organizations use in order to decide the direction of the research strategy.

When referring to the definition of the strategic guidelines of the PRI, Interviewee A stated that the government publishes an official document that reflects the main strategies to follow in the matter of research for the next two years. The purpose of the document is to define the strategic areas or prioritized areas. Some typical strategic areas, according to Interviewee A, are Petroleum, Nanotechnology or Climate. However, the area in which this researcher works has a focus on scientific research in *any* field, therefore following a strategy of open calls for independent research in any scientific field and projects qualify based on the main criteria of scientific quality. Some main criteria that is considered when defining the strategic guidelines that support the best basic research, according to interviewee A, includes, that the research projects promote gender balance and that it has some element for recruitment and development of new researchers. Finally, interviewee A stated that guidelines for research strategy in this funding scheme do not change much in time given that it is open to all research fields.

Interviewee B agreed that the PRI has a specific overall research strategy based on national needs; however there are over seventy different programs in the PRI and each one of them

has their own strategic or program plans. For the specific funding scheme of interviewee B, the program works as a project in the sense that it has a specific duration time (2004 – 2013), and it is concerned with climate research. Strategic guidelines for this unit are defined by a group of scientist and researchers who make an overview of the available information that shapes a background document. The document is based on processed information form papers, international documents and expertise of the group of scientists on the topics. The guidelines in this case are reviewed at least once during the duration of the program. There is also an action plan for each year, the purpose of which is to stay updated since research needs may change over time and there could be a need to shift priorities.

On the private side of the research interviewee C from the PMO gave an understanding of the experience of being the research manager of a young and growing company. This led the interviewee to work in a portfolio and take as many projects or customer assignments as the department could handle with the limited amount of resources they had. Defining strategic guidelines was responsibility of interviewee C with advice and discussion of the CEO and in some cases the main management. Interviewee C always focused on the main organizational strategy; however in this case the strategy did not consider research projects but was more related to organizational growth and profitability.

Furthermore, Interviewee C stated that the guidelines were made up as things came up, it was a new, small company. It was a pioneering company. Therefore guidelines changed very often because everything was new and in process. However, since its inception the organization has grown considerably and it is now a more consolidated company and things are starting to be wider, bigger, stronger, including both strategy and guidelines. While there is always room for improvement, certain types of research projects that were undertaken at the beginning – such as endeavouring to new markets – will not be conducted further there because the company is better established now. Currently, there is a bigger focus on developing competences.

Data from documents of the TO states that after the project portfolio management of research and development process was introduced, there was high involvement from the top management. The top management of the various business units were responsible for

making sure that superiors practiced portfolio management and management at each decision point of each project.

5.2 Project Evaluation and Selection

This section of the interview was related to the evaluation of project proposals and eventual project selection.

Interviewee A stated that the overall guideline definition for project evaluation is responsibility of the administration in the PRI and that for each research field there is an advisor who is responsible for this.

Two challenges in this process, identified by interviewee A, are related to creating the panel of experts who will assess the project. The first challenge is to find enough qualified experts to form the evaluation panel, i.e. generalists, and the second one to find a common date for them to meet once a year. These challenges are overcome by starting to prepare early for the evaluation process and set a date in advance, also by establishing pools of experts even if not all experts would be requested, would provide a way to pick the best mix of experts.

Project selection also implies that some projects, even if they are good, may not be selected. In this regard the interviewee stated that those projects that are good but for some reason did not make the final selection stage, may apply to get funding from other areas or programs of the PRI or even reapply the next year to the same funding scheme. The complete process from the time the guidelines are defined, until the project gets approved and ready to start up may take up to one year.

Interviewee B also commented on the evaluation process of the respective business unit. In this case there are two sets of guidelines to be considered. There is one group of guidelines that applies to every project of the PRI and one group of guidelines specific for each topic of the call of proposals. For the department that the interviewee coordinates responsibility of developing these guidelines falls under the interviewee's job description.

The evaluation process includes finding experts to evaluate the proposals. The PRI states that these experts, who form the panel, should be of an international background in order to avoid conflicts of interest. The experts read the applications individually before getting together in a yearly meeting, where they reach a consensus and make a report for each

project. After the reports are made the projects are ranked. Some of the challenges as perceived by interviewee B in this phase are the existence of conflicts of interest even between international panel members; also there is the difficulty of finding the required experts to assess the projects. The main task to be done in order to overcome these challenges is to invest more time in finding new experts that fulfil the requirements for project evaluation. The process from the moment the proposals are received until the final decision is made lasts up to three months.

Guideline definitions for project assessment are responsibility of interviewee C along with the *second in command.* They decide how a business case should look. Interviewee C stated that this is a process that varies quite a bit, which is an area of opportunity and improvement. The project evaluation process starts when the CEO calls for a project and expects a business case, a document; he reviews it and then decides whether he backs it up or not. First, a proposal is made. Then, it is sent to the CEO who will review it, give comments and back it up. If there are any changes to be done, they are done and then sent further for review. Once the proposal is approved the project starts.

The main challenges faced when evaluating the project proposals, according to interviewee C, are that the format of the proposal varies a lot and the approach is very different from case to case. Since it is a new and on-going process, there is nothing to compare this to, so it is basically done against personal criteria and experience. He stated that:

> *'In research projects it is very hard to tell what the future will be, especially on the benefit side so we don't see the benefit side in terms of money. More resources could be invested in finding out the benefits side than on the project itself, so we do simple cost estimation and make a loose estimate on the benefits and expectations trying to keep it real. How much money, time could be saved with a new system, for example?'*

For interviewee C a way to overcome these challenges is to be more specific and formalistic in order to make things more systematic. From his point of view lack of experience is a universal issue and there is nothing to do about it except trial and error and be as explicit as possible with the selection criteria. This makes it easier for those proposing to isolate the right arguments and leave out the bits that do not fit. Furthermore, interviewee C added that having an unclear picture of the selection criteria also has a good point there is

freedom of choice and freedom of action. Having worked also on the public sector he added that:

'The public sector keeps criteria as open as possible for this same reason.'

When it comes to project rejection interviewee C stated that a project can be turned down because it is too costly; however, it does not mean it is bad and in fact it could be excellent if the resources were available. A project can be reshaped if the project is good and too expensive or good but does not fit completely the expectations. On the other hand, if the project is an idea that needs more work and the trend is good to support it, then it can be put aside and wait. However, interviewee C emphasizes that managers should keep in mind that if a project is a good idea, then it should be grabbed otherwise someone else will use it.

In this private organization case, the time it takes from guidelines definition to project approval and start up depends on the size of the project. Interviewee C said:

'If it is small it may as well start the next day. But larger projects require more consideration. There is a rush once a project is decided to be done, to do it now. But then there is the issue of doing it and doing it for less money. In that case you could wait until a better resource is available which could take a month or two.'

In the TO the portfolio management used a scoring model where managers worked with scoring guidelines in order to do resource allocation. Furthermore, a specific position for portfolio management, scoring and reporting was created. The list of priorities was then passed to the development projects and resource owners in the various departments and business units. The introduction of the portfolio management process contributed to achieve a more appropriate mix of 'valuable' projects as well as a more optimal allocation of resources in the business units.

Before the introduction of the portfolio management process one business unit would have over 50 simultaneous research projects; many of which had delays. After the implementation of the portfolio management process, it was reduced to a dozen of parallel projects. Thanks to portfolio management, projects had more management focus and within a year the frequency of product launch had quadrupled. In addition, the average 'time-to-market' for each research project went down from two years to less than one year.

Later on the portfolio was balanced by scoring to on-going projects which resulted in a decrease in the 'time-to-market' to only a few months.

In 2001, a simplification of the scoring model was introduced by focusing on fewer criteria so that ideas and projects were easier to score and compare. First, there was a reduction from six to four criteria: Feasibility, Cost, Payback and Market attractiveness. This was then further reduced the following year in a graph that mainly showed market attractiveness, feasibility and profitability.

5.3   Project Control

This section deals with the control measurements and methods employed to evaluate the progress of the research projects; which in turn ensures project success.

The way that the PRI follows up on project progress, according to Interviewee A, is by means of written process reports that have to be submitted electronically once a year by the project manager. The reports are read by the advisor in charge of the funding and if approved the funds for the next year will be allocated to the project. If the report is not approved, then it should be reviewed by the project manager and resubmitted.

Some challenges associated with this stage, as identified by this interviewee, stem from the research team not submitting the report on time or whenever the project suffers major changes which should be reported to the PRI immediately. Currently, the way to prevent this from happening is to stop the payment to the research team unless they deliver the reports. Also failure to provide project reports may lead to project termination.

In the business unit of Interviewee B, project managers of the research team have also to submit a yearly report for control purposes. However, funds are divided in three payments per year. At the end of the project the team should submit another final report within a month of project termination; a final payment is bound to this final report.

For the young research unit where Interviewee C worked, control mechanisms are supported by uncertainty analysis for small projects. However, they rely on notes with the names and tasks and made sure that people do not have too many or too few assignments. Tasks are distributed between people to balance them. The system is simple and visual. As

the company has become bigger, things are based on a reporting system, it is all based on reporting hours.

As mentioned before, the TO highly relayed on a continuously optimized scoring model. Furthermore the documentation states that achieving this reduction in the time to market also followed the introduction of PM procedures for continuous measurement of launches and completion and recording of other project data.

5.4   Final Feedback

The last section of the interview deals with questions regarding the end of the project, project success and final reporting.

In the business unit that interviewee A works project success is measured in terms of the final report and the scientific development or achievements. They take into account how many PhD positions were created during the duration of the project, the number of publications and journals, oral presentations given by the research team, whether the project supported the need for gender equality and balance. Whenever a project is not considered successful, there are no immediate penalties for the research team

   'as long as they have tried their best';

however the interviewee mentions that it may affect the team's future applications.

The final feedback of the project's success is important both to the Project Manger of the research team and to the business unit where interviewee A works. The PRI is about to evaluate this particular department in order to look for projects with a successful outcome to present. This is useful so that the department can secure and perhaps increase the funds received.

For interviewee B project success is measured in many levels, some of them which are similar to the ones stated by interviewee A. In her program they look for criteria such as scientific recruitment, PhD positions created, publications – especially international publications – and integration of women into science. If a project is not successful, then the main penalty is that the final payment is hold back. However, she stated that this is tried to be avoided by making adjustments and altering project goals during the progress of the

research project. During the final feedback of the project, this department helps the research group to convey the results to the end users, for example, the environmental managers, since the research unit is connected to climate research.

In the private institution, Interviewee C interprets success from a personal point of view in terms of whether the project was 'well done'. However he also states the importance of looking at how the project will be used in the future; whether it will be relevant, in line with the needs, and sustainable, and whether it will add long term value.

Final feedback is an opportunity area for this organization. Written reports are not always read after they are archived. IT reports present too much information which may be also hard to find, they are not user friendly. The problem is to know *what* to report, *how* to put it and *where* to find it. One way the organization deals with these issues is by identifying *who* has the knowledge. They create a knowledge network that helps spread the knowledge, specially the tacit one. The company has a culture of sharing and everyone is available to answers questions of other employees about the projects that they have been involved in or the problems they have faced in their projects.

The introduction of the portfolio management of research projects in the TO not only helped reduce the time to market of innovations, it also had a bigger and more sustainable impact. Now, the TO uses portfolio management processes also in its IT development projects. The TO identifies future challenges in the field of portfolio management of service development in the collaboration with third parties and service providers. This is also a trend seen elsewhere in the ICT industry and it is often described as 'open innovation'.

6 Data Analysis and Discussion

This chapter is based on the literature research, document analysis and interviews with the representatives from both the private and public organizations. In the previous chapter, Data Gathering, the facts were presented in a particular order, i.e. according to the structure of the interview. In the current chapter, the information previously introduced is structured in a different way; it is categorized in three major areas of interest or common points between the interviews.

For each of these categories the information is then studied following three steps. First, my personal interpretation based on the factual data is given along with a summarizing table of the data interpreted. Next, the analysis of such interpretation according to the theoretical research is presented. Based on these steps, asseverations are drawn and their implications are, finally, discussed. The analysis and discussion are linked in this section as these terms are considered as logical to combine for this report.

6.1 Public vs. Private Strategic Alignment

In the interviews and document analysis, strategy was mentioned as means to define the research approach of the organization. As was explained by the interviewees, their strategic research is set by both a higher strategy and a more local one, given by the research unit as such. However it must be noted that the focus of the higher strategy (governmental or organizational) is different in both organizations.

The PRI follows a governmental strategy, which is already research oriented given the nature of the institution. However, both the PMO's and the TO's organizational strategy has little to do with research and more related to business growth and market positioning. In these private institutions the organizational strategy is aimed at keeping the business up and competitive in the market.

Besides this, the research units in the private and public organizations have their own research strategy. It was possible to identify from the interviews that the programs of the PRI base their strategy on scientific basis, whereas the PMO has a strategy based on market opportunities. This difference in the research strategies aligns with the different perspectives that these organizations have regarding success of the project. This issue will be discussed further in the later sections.

Another interesting point identified in the interviews is that the life cycle of the guidelines varies from both the private and public organizations. In the PRI, the guidelines seldom change and are subject to the revision of the strategy in case there has to be a change in the priorities of each program. However in the PMO, the guidelines were constantly changing and being reviewed even as the projects were developed. This may, however, be interpreted not only as a reflection of the nature of the organizations, but also as a reflection of the maturity of the organizations. It is worth remembering that the PRI is a well-established organization that represents the higher authority on the focus that research should take in the country. On the other hand, the PMO was a newly formed organization which was on the process of growing and finding opportunities to become a leader in its industry.

Little was found on the document analysis from the TO on this regard. However the document does specify that higher management was involved in the introduction of the project portfolio management process in the research area. This is interpreted as that there has been the presence of the organizational goals along with the research goals. This interpretation is given, since top management support will reflect the organization's goals on the different areas of the organization. Furthermore, the decision of establishing a portfolio management of research projects (PMRP) process within an organization and having the support of the higher management reflects the importance of this matter in the organization's strategy.

The summary of the previously analysed and interpreted issues can be seen in the following table:

Public Perspective	Private Perspective
Strategy: • Government strategy • Program strategy	Strategy: • Involvement of the top management (TO) • Organizational strategy (PMO) • Research strategy (PMO)
Guidelines based on: • Scientific merit • Scientific research	Guidelines based on: • Research of new markets opportunities
Guideline review: • Very seldom or with strategy revision	Guideline review: • Constantly changing (PMO)

Table 3: Public vs. Private take on Strategic Alignment

In order to understand the impact of having an alignment between the strategy and the management of the portfolio it is useful to recall the underlining reasons why organizations undertake research projects. According to the literature reviewed, since end of the 19th century there has been an increasing interest in organized research and development in societies (David, Hall, & Toole, 2000). The belief is that organized research and development leads to economic growth and welfare. On the other hand, the private sector has widely relied on research as means to develop successful product and process innovation in hopes to reach and sustain business advantage. The organizations analysed in this thesis operate within this context and therefore seek ways to perform research projects.

The PRI, according to the analysis of the interviews, functions within this context by having as a main strategy to determine the direction that research projects should have in the country. On the other hand, the two private organizations have a strategy that points to competitive advantage and business sustainability through product and process innovation and exploration of new markets. Therefore it is possible to say that the organizations here presented have the implementation of research projects, either explicitly or implicitly, embedded within their strategy. Furthermore, they use this strategy as means to define focus areas of the research and the nature of the projects that should form their portfolios, i.e. whether they should be in the scientific, environmental, technological or market areas, to name a few.

In the theoretical background of this thesis (Chapter 3), some authors such as Linton D. & Walsh T. (2002), McNally (2007) and Meskendahl (2010) stressed the importance and role of organizational strategy as means to develop and shape the research strategy. The priority established by the research strategy, along with the dynamism of the environment, makes developing the right project at the right time a matter of great importance.

From the strategic alignment perspective it is possible to say that the organizations here presented shape their portfolios to closely reflect the organizational or research strategy. These portfolios will, therefore, have a focus on choosing the *right* projects, i.e. those that rightly reflect and support the strategy. How these projects are selected in these organizations will be explained in the next section.

Also to be considered is Figure 6: Adapted general framework (Meskendahl, 2010). The model states that strategic orientation, applied to the structure of the portfolio, leads to business success. Therefore, portfolio management of research projects is seen as the link between the organizational strategy and business success. Within this perspective, the organizations have a great tool in the process of PMRP as means to achieve their organizational goals which are shaped by the main strategy. Strategy also gives an overall, broader picture – a systemic understanding – about not only the individual parts that constitute a system, but also the interconnection between the parts (Senge, 1990).

Based on this analysis, the following asseveration is drawn and discussed:

- *Having an alignment between portfolio management of research projects and the organizational strategy and/or program strategy can be beneficial to the organizations.*

To prioritize research projects as part of the organizational strategy may or may not be explicitly stated by the organizations. In the cases here presented it is explicitly part of the PRI strategy. On the private side, however, the strategy does not specifically address research projects. It is, in rough terms, aimed towards business growth. Nevertheless, the private organizations have chosen to carry out research projects as means to support the organizational goals. Therefore it is possible to say that one way or another, research is part of the organizational strategy and the organization benefits from it.

Once it is clarified that research is part of the strategy, it is important to discuss the implications that this can have over PMRP. First, the strategy can shape the direction of the portfolio and, therefore, the nature of the projects. This validates the projects' existence in the portfolio. The projects exist not as individual entities, but as part of a bigger system which they help function properly. Having the strategy shape the portfolio ensures that the latter complies with the organizational goals.

Second, the alignment of strategy and PMRP serves as a reference point when changes have to be done. That is, whenever the organizational goals change, the portfolio can adapt to reflect the new strategy. Furthermore, in the case that the portfolio works inefficiently, it is possible to regain focus by looking at the main strategy and adjusting it.

On the other hand, if this alignment is very rigid it may deprive the research department from its ability to respond in an agile way to changes in the environment. This can be a pitfall when the organization is slow to react due to characteristics such as organizational culture, rigidity of the processes, etc., and the research unit has to comply with the strategy.

Therefore it is important to maintain a flexible alignment to the strategy as much as possible. This is the case for the cases here presented. In the PRI the PMRP followed the changes in the organizational strategy, but it was also reviewed on timely basis as well as the unit's strategy. In the private sector, the example from the PMO showed that in a young organization the strategy changes more often and it is made up on the go and this was reflected in the PMRP process.

Both organizations benefit from their own approach. In the public sector, the well-established organization relies on formal methodologies which allow standardization between the different programs; there is a fixed point of reference. In the private sector, a young organization benefits from the flexibility of not having a rigid process and allows it to react and adapt to the changes that characterize its environment.

Whether it is rigid or flexible, the strategy represents the focal point from which the portfolio will be managed and it shapes the content of the portfolio.

6.2   Public vs. Private Project Evaluation and Selection

When it came to project evaluation and selection, the interviewees and document analysis of the organizations studied in this report gave different answers. On one side both, departments of the PRI agreed that the guidelines came both from the organization's general dispositions and the department's own guidelines which in turn are defined by the research strategy. According to them each program has its own unique research strategy; however they comply with the main organizational goals as well.

Information from the PMO reflects this behaviour. While the top management is involved in the formulation of the evaluation and selection guidelines, the responsibility mainly falls on the Research Manager. Furthermore, it was stated by the PRI and the PMO that the managers and researchers experience is of great use when evaluating and selecting projects. Managerial experience becomes a tool to support the established guidelines which points

out that established guidelines alone are not enough to meet the evaluation and selection process.

Defining and implementing the evaluation and selection guidelines is of major importance to the PMRP process. However, such activities come with challenges associated with them. The interviewees of the PRI agreed that the biggest challenges are first, to find enough qualified experts to form the evaluation panel, and second, to find a common date for them to meet once a year.

First, finding the qualified evaluators is challenging because they should be both generalists and knowledgeable in the areas of interest of the research proposals and experts with these characteristics are a scarce resource. Furthermore, there is the issue of dealing with conflicts of interest: a possible candidate for expert may have been part of a project proposal, thus, making him/her an unsuitable candidate for the expert panel. Second, once the experts have been identified, they should meet once a year to discuss, evaluate and score the proposals and finding the time to achieve this is complex given the difference in their schedules.

Currently the best strategy the PRI has against this challenge is to allocate more time and human resources into the selection of the expert panel. Scheduling and recruitment of experienced researchers is not within the scope of this thesis. However, the need for expertise can be linked to the project success and success criteria from the PRI. This will be later on the thesis.

On the private side the challenges have a different source other than that in the public sector. For the PMO, the biggest challenge is that the evaluation and selection process is informal because, as mentioned before, the organization was just developing the R&D department. With the guidelines constantly changing and being made up as issues came up, there was little to compare against. Therefore, the PMO had a challenge to establish a more formal process. However, it can be assumed that has to do with the level of maturity of the organization, which was at the moment, new and growing.

The TO's biggest challenges were mainly described as existent prior to the introduction of the portfolio management process. At that prior point of time, they had far too many

project with delays and conflicting resource allocation. With the introduction of the PMRP process the number of projects was reduced as well as the *time-to-market* time improved. The TO relayed on a scoring model to achieve project evaluation and selection which also helped them find the *right-mix* of projects.

The following table presents a summary of the previous identified issues:

Public Perspective	Private Perspective
Evaluation and selection guidelines: • General management guidelines • Program guidelines	Evaluation and selection guidelines: • CEO guidelines • Research manager
Challenges in evaluation process: • Finding the expert panel (generalists) • Conflicts of interest • Managing schedules	Challenges in evaluation process: • Process is informal (PMO) • There is little to compare against (PMO) • Too many project with poorly allocated resources (TO)
Proposed solution: • Allocate more time to the selection process	Proposed solution: • Trial and error (PMO) • Scoring model (TO)

Table 4: Public vs. Private take on Project Evaluation and Selection

Theory that was previously introduced in this thesis states that there are several models that support the evaluation and selection of research projects, and it is up to the research team to decide which model or guidelines to follow when evaluating and selecting projects. Most importantly, the chosen method should be able to serve as mechanism to ask questions, collect information and share opinions (Chien, 2002). In the case of the PRI, this is reached through the yearly meeting from the experts. In them, the experts are able to share their evaluations, discuss and find common grounds for project scoring and prioritization. The PMO addressed this issue through discussions between the Research Manager and other stakeholders of interest.

According to Chien (2002), strategic methods for project evaluation and selection give the best results in portfolio performance, which, therefore, may be a driver for business success (Meskendahl, 2010). The theory here presented can be traced to the organizations analysed; the methods used by the organizations are of a strategic nature.

Furthermore, in both the private and public organizations the involvement of the research manager is present while keeping in mind the overall program and organizational guidelines. According to McNally (2007) the manager's dispositional traits have a direct impact on the

dimensions of the PMRP process. Therefore, it is possible to say that the guidelines and project evaluation and selection, while following a bigger picture, may represent a reflection of the manager's experience and style, as can be seen in the Table 1: Manager's personality traits and their influence over the dimensions of PMRP by McNally (2007). However, it should be noted that in literature there is a clear tendency to study formal methods of evaluation and selection. Manager's personality and other social traits have a lower presence in the theory. The organizations analysed in this paper, stated the importance of the expertise of the people involved in the PMRP process. Due to this, it is assumed that the process will reflect the experience, expertise and personality traits of the decision makers to a certain extent.

Both strategy and experience are part of the selection process. The organizations presented in this document first establish a general strategy (which may be focused on research, welfare, growth, competitive advantage or a mix of them) and a research strategy; then, based on this strategy they define the guidelines for project the evaluation and selection process; next, the process is implemented at to which point the experience of the managers and evaluators comes in place when there are decisions that cannot be considered in the guidelines; finally, the projects are scored according to this evaluation and the final selection is done.

Project evaluation and selection is one of the main activities performed in the PMRP process. From a system thinking point of view (Michael C, 2003), the performance of the portfolio depends on all the projects that form it as well as the interactions between them. All these relationships should be considered in order to understand the portfolio as a whole; hence, the best projects not necessarily make the most optimal portfolio (Chien, 2002). Given this, the portfolio should be focused on choosing no the *best* projects, but the *right* ones; the ones that support the research and organizational strategy.

This systems thinking also applies to the complete PMRP process. While evaluating and selecting projects is a main process, the portfolio should be seen as a whole. The interactions between all the activities of the process should be considered by the managers in order to understand the portfolio (Senge, 1990). The main activities of the process can be seen in Figure 14: PMRP process, base model for interview, presented in the Methodology

chapter of this thesis. While all the activities are of great importance to the performance of the portfolio, the focus of this thesis is in the project evaluation and selection activity.

Based on this analysis the following asseverations are drawn and discussed:

- *Project selection is benefited by combining both strategic methods and the decision maker's experience.*

Organizations rely on sets of guidelines to evaluate and ultimately select the research projects to be integrated into the portfolio. These guidelines give the organization the point of reference on how to evaluate and select the right projects that will fit the goals. The importance of relying on strategic methods has previously been established. However, if the organization solely based their decisions on formal scoring methods for the selection process, the selection process may fall into rigidity and make it hard to respond to changes and uncertainties.

Two situations where a combination of strategic methods and experience can be useful in project selection and evaluation have been identified. The first one is when two or more projects have the same scoring; the second is when the information available to evaluate the project is unclear of hard to reach.

For the first scenario, the evaluator's experience may be useful to apply a proper evaluation and, ultimately, reach an adequate selection of the *right* project. Experience and personal traits of the decision makers helps them choose between two projects that otherwise may seem equally *good* when scored against strategy-based guidelines. In the second scenario, a new organization facing a constantly changing environment may face the challenge to find reliable up to date information to evaluate the project and have little documentation to rely on. In this case, the experience and expertise of the evaluators can be the decisive tool to evaluate and select a project.

The combination of a strategic evaluation and selection method with the experience of the manager can be helpful and bring flexibility to the process. If the selection process is supported by these two tools, the organizations can dynamically assess the projects, give them weights and select the best given the current situation.

- *Portfolio management of research projects is a process of which boundaries go further than project selection.*

When talking about management of a portfolio of projects the first activity that comes to mind is the one of project selection since it is the most obvious to perform when creating a portfolio. However, before selecting a set of projects that should be part of the portfolio, there are a number of other tasks that should be considered. Moreover, the management of the portfolio does not finish when the projects come to an end. The process is quite broad and it goes from the definition of the research strategy to be followed – passing through project evaluation and selection, resource allocation, project termination and rebalancing of the portfolio – to the redefinition of the research strategy has to be done.

Such activities must be performed constantly and dynamically based on changing and sometimes even uncertain information. The dynamism that surrounds the process of portfolio management of research projects requires for the research managers and executors to have a broad understanding of the process, the organizational environment, strategic alignment as well as the characteristics of the individual projects and the interactions between them and the other processes. Moreover, this holistic understanding should be adapted and reviewed with each decision gate such as project termination, project completion or project start up.

It became clear during this research that this process should be addressed through a holistic approach based on a systemic thinking. It starts as early as with the definition of the organizational and research strategy, passing through project evaluation and selection, resource allocation, project control – among other tasks –, until the finalization of the projects, rebalancing and passing of the information generated – to name a few – before it starts all over again. Therefore, the selection of individually good projects not necessarily constitutes a good portfolio; and good project evaluation and selection does not guarantee the success of the portfolio.

Portfolio management of research projects is, in fact, a loop. This cycle extends its boundaries beyond simple project selection. However project selection is one of the key tasks in the process and the one of interest to this report.

6.3   Public vs. Private Project Success

During execution, success criteria can be measured and controlled in order to influence the final outcome or success of the projects. However, measurement of success according to these criteria happens at the end of the project and in the best case it can continue to be measured long after the termination. The data gathered in this research project shows that this broader dimension has come much more into consideration by the organizations.

Both interviewees from the PRI identify the same success criteria, such as regular reports, number of PhD positions created or the existence of equality in gender, as explained in the previous chapter. During the execution of the project these criteria are managed through recurrent controls and feedback. In case the controls throw negative results, the funds for the project may be terminated. If all the controls are positive the project goes on and the initial, operational perspective, of the project is considered a success. Whenever these criteria were not met by the projects, the PRI focuses on the knowledge generation that could stem from the project as well as the effort place by the research team. In addition, even if the project had been perceived as failed, the PRI considers that this is a risk that has to be taken in the research industry.

The PMO perspective has a similar perspective. Success criteria was established by the research manager, and it was measured initially based on the time, cost and quality dimensions. However, the PMO also focused on medium and long term perspective and specifically mentioned the operational, tactical and strategic impact of the project which was also discussed in the literature review. The risk of having an unsuccessful project, according to the PMO, cannot be avoided especially given the uncertainty of research projects. The knowledge generated by these research projects was translated to business opportunities and possible prospects of market growth in the PMO. Sometimes, the research was successful and the company could go ahead and venture into new markets. Sometimes, even after venturing into new markets, the company found it to be not a suitable investment and terminated the project. This, once again, is considered as normal and necessary when doing research.

Finally, after termination, something has to be done to the knowledge generated by the research projects. This is also part of the transcendence of the project success further from

the operational perspective. In order to talk about a tactical or strategic perspective, the outcomes of the project must be transmitted or employed somehow within the organization or among the different stakeholders.

The PRI, dealing with public research, focuses on evaluating the knowledge generated and using it as a basis to evaluate future research strategies and proposals. The outcomes are also used to justify the need for funds from the government in the future. Moreover, the organization tries to help researchers to convey their results to stakeholders of interest, i.e. end users of the information produced.

For the PMO, the transcendence of the project's outcome comes as sustainable business opportunities and competitive advantage. Therefore, it is important to share the knowledge among the organization and have implemented a simple method where employees are always available to share their knowledge with others and are well identified as the knowledge holders. Through this it is ensured that the knowledge is available and spread, since written or electronic methods are considered to be not so effective in the same regard.

When it came to success and knowledge transfer, little was found in the document analysis regarding success in the TO; therefore it is not included in this section.

The following table summarizes both public and private perspectives previously analysed.

Public Perspective	Private Perspective (PMO)
Success criteria: • Submission of regular reports • Number of PhD positions created • Publications in international Journals • Conferences • Gender equality	Success criteria: • Personal point of view • Medium and long term perspective • Generation of business opportunities • Competitive advantage
Perspective on failure: • Focus on whether the research team tried its best • It's a risk that has to be taken to generate knowledge	Perspective on failure; • Try to avoid it on earlier project stages • Necessary when doing research • Knowledge has been created
Knowledge transfer: • Internal, used for program evaluation and future funds • External, knowledge is transmitted to final user	Knowledge transfer: • Implemented a culture of 'WHO has the knowledge?' • Focus on tacit knowledge transfer through availability and communication

Table 5: Public vs. Private take on Project Success

Perhaps, project success is one of the hardest dimensions to evaluate in a project. As stated in the literature review, traditional project management research focused mainly on immediate results, which could be limited to time, cost and quality (Samset, 2003). This has been the case for many organizations, until a broader vision stated to get noticed by both organizations and researchers on the topic. Now it is possible to talk about success in the medium and long terms, and even from different stakeholder's perspective. It is worth to remember the model previously presented where Samset (2003) categorized success depending on the point of time when it is measured. These perspectives were presented in Figure 9: Different measures of success in three different perspectives by the same author.

Success criteria established by the PRI can be studied from Samset's approach. For the public organization, the immediate, or *operational*, success indicator is that the project finishes when stated and that the control and final reports are delivered as expected. *Tactically*, criteria such as the amount of international publications the project has produced increase the usefulness of the project. Through this, the knowledge generated by the research project goes further than just bringing benefits to the organization or the nation. Knowledge is spread beyond the project's context and it becomes source of information for future research related to the topic; hence, increasing its relevance and impact. *Strategically*, criteria such as gender equality and generation of PhD degrees have a societal effect.

First, the creation of PhD positions supposes the generation of experts in the topic which then could become evaluators for future research projects both nationally and internationally and who can continue to perform research projects in the future. Second, the project itself, through its results, generates knowledge on the topic that can be applied both in public and private organizations thus contributing to the economic growth and welfare of the nation. Finally, PhDs and gender equality ensures that the country has enough educated people to sustain future research needs and to sustain the nation's welfare.

Overall, the model presented by Samset (2003) is greatly applicable to the PRI and a good way for the organization to place its projects in a broader context when it comes to success.

The PMO can be analysed in a quite similar way. The *operational* success clearly comes through evaluating the termination of the project from a time, cost and quality perspective. The representative of this organization also mentioned that besides from these obvious criteria he relies on his personal perception to assess success. This personal perception could be a link to assessing a longer perspective of success; for example, from the *tactical* perspective, whether the project is relevant or not on the medium term. In addition, the interviewee mentioned that these tactic and *strategic* success can only be assessed as time went by.

One example given for this is a research made to expand to a new market. While the initial expansion seemed a good organizational step, with time, developing in this new market proved not to be relevant or sustainable so the project was terminated. However, from a learning perspective, the project was not considered a failure because it provided an insight on the market and the path that the organization should follow that would have been not possible to achieve otherwise.

The previously defined perspectives on success gave a clear understanding that a project which may seem as unsuccessful in the short term, perhaps because it took did not comply with the time constraint, it can still be considered successful in the medium or long term.

On a different understanding of project success, it was particularly interesting to learn that both the PRI and the PMO shared the perception of the purpose of doing research: generating knowledge. Even when the project failed to comply with the success criteria and could have been labelled as not successful, there was more to consider. First, organizations agree that risk of failure cannot be avoided in research projects. Second, research projects produce knowledge to the organization, whether it was in the form of learning, experience or information.

While at first sight the success criteria of both private and public organizations seem to have different nature, it is possible to say that they agree in the knowledge generation factor brought by research projects.

Given the previous analysis the following asseverations regarding project success are drawn and discussed:

- *Project success depends on the perspective from which it is measured.*

As stated before, success in projects depends on the perspective from which it is seen. This perspective reflects both the point of view of the different stakeholders and the point in time when it is measured. This applies to both public and private organizations that perform research projects. Quite obviously organizations share the immediate perspective of the traditional criteria of project success, such as time, cost and quality; this reflects the perspective of the organization itself. However, other perspectives can also be considered.

On a medium and long term, the success of the project depends on other criteria, as seen in the literature. These perspectives also take into consideration a broader set of stakeholders. For example, the relevance of the project may be of interest not only to the project manager, but the research manager and even tax contributors, in the case of a public organization. The sustainability of the project and the extent to which it covers the end user's needs can also be considered as a success criteria on a longer term; and in the case of a private organization can lead to sustained competitive advantage.

Therefore, a project that may not be successful from the project manager's point of view may in turn be successful for the end user. This would only be discovered with time.

- *Knowledge, the most basic outcome of research projects, is of importance in both private and public organizations.*

As stated before, the concept of project success is relative. This is particularly true for research projects given their uncertain nature and the impact the results may have in the future. Organizations that perform research projects do have an expectation for them to produce certain benefits. In public organizations, the benefit comes as an increase in the knowledge base of the nation which later on leads to welfare. In private organizations, the benefits of a successful research project come in business opportunities or breakthroughs that then lead to competitive advantage. However, not always the projects succeed as expected and, thus, produce the long term benefits.

Regardless of this, organizations continue to perform research projects. There is an intrinsic understanding that the risk of having a failed research project is unavoidable and worth taking. This is because one way or another, the project will create a learning experience to

the organization. This learning comes in the form of information, whether it is the expected information to obtain or not. The information, hence, adds to the experience and the knowledge of the organization regarding the process. Whether the project produces intended or unintended results, the learning process is enriched through the knowledge generated by performing research. The importance of undertaking research lies in this.

6.4   Revisiting the Research Model

In this final stage of this thesis project it is be useful to go back to some basic definitions underlining the research. As taken from the definition presented by Cooper et al. (2002) the process of portfolio management of research projects includes a series of decision making processes such as looking at the entire set of projects and comparing them to each other; making decisions to *kill* or *go* on individual projects continuously; taking resource allocation decisions and developing a new research strategy for the organization. With this definition, supporting theory and the previous analysis and interpretation there are some key findings reached in this report.

After careful consideration of the information presented throughout this report, I would like to present a reviewed version of the research model presented in Chapter 2, Problem Formulation. As stated earlier in this project the initial model was based on my assumption that strategy influences the process of portfolio management of research projects which, in turn, lead to knowledge being generated. This assumption was based on the nature of research projects. First, research projects have a context of uncertainty associated with them; strategy provides a point of reference to tackle it. Then, the outcome of research projects is intangible; most commonly in the form of knowledge. See Figure 1: Research model.

Since this investigation was approached with an open mind, it was expected to produce findings not only relevant but enriching for the initial assumptions. Therefore, I present the initial research model reviewed to include these topics:
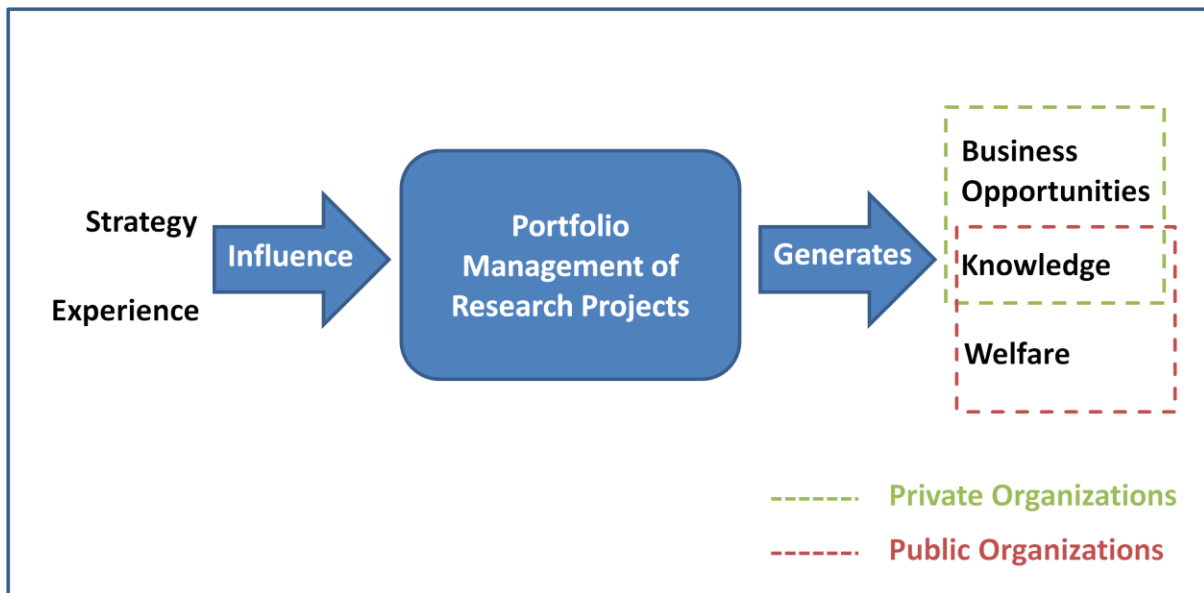
Figure 15: Reviewed research model

The model now reflects the influence of not only organizational strategy but also managerial experience to the portfolio management of research projects process. Strategy provides the focus that the research projects should have, and acts as the point of reference to which the PMRP should be aligned when the environment changes. Experience serves as a decision tool when the formal methods fail to model the real world due to uncertainty or unavailability of information.

On the other end of the model, PMRP now is considered to generate not only knowledge, but also business opportunities and public welfare. This addition obeys the fact that the thesis presents an example of both the private and public sectors. Private organizations aim at generating business opportunities. Research projects are performed to find new markets, improve processes or find grounds to incur in new product development. Public organizations aim at generating welfare and national economic growth. Research projects are undertaken to increase scientific and technological knowledge as well as to form new experts who can contribute in future research projects.

The initial assumption, that PMRP aimed to generate knowledge, is still a central part of the model. Evidence has shown that organizations, both private and public, agree that generating knowledge is the basic objective of research projects.

I believe the model now reflects better the reality of the context in which PMRP develops.

6.5 Summary

This chapter complemented chapter 5 by interpreting the factual data and analysing it. Based on this, the findings were presented and their implications discussed. Studying the information in this manner was useful to have a better understanding of the context in which research projects develop. Moreover, it was possible to identify areas of improvement to the initial research model, thus, enriching the learning process. The final remarks and future areas of possible research are presented in the next chapter.

7 Conclusions

The present report is the final thesis for the Master of Science in Project Management. The thesis was conducted for the department of Industrial Economics and Technology (IØT) at the Norwegian University of Science and Technology (NTNU) during the spring semester of 2011.

The importance of the topic of portfolio management of research projects became evident to me through literature review and discussions with researchers and professors from research institutions and industrial organizations. More and more public and private organizations rely on research projects and arrange them in portfolios as means to deliver results. Research projects generate knowledge which helps organizations stay updated in new technologies, methodologies, processes, etc. The thesis began with the assumption that the organizational strategy influences the management of research portfolios which in turn generates knowledge. With this in mind, organizations from both the public and private sector were studied in order to have a better understanding on how the process is conducted in these contexts.

The study was supported by theoretical background regarding portfolio management of research projects and the previously described initial assumptions. Additionally, documents were analysed and interviews conducted to representatives of both the public and private sector. Finally the information gathered was interpreted and analysed which led to the final findings and the discussion of their implications.

The objective of the thesis – to have a better understanding of the PMRP process from a public and private perspective – was achieved. The thesis allowed to not only give answer to the research questions, but to complement them with interesting findings and even identify areas of interest for further research. In order to demonstrate this, it is important to go back to the research questions and link them to the findings that give answer to them. More background on the research questions can be found on Chapter 2, and more insight on the findings that address these questions can be found in Chapter 6.

The question "How do organizations perform the portfolio management process?" has its basic answer in the description of the process step by step. While this process was addressed through the interviews and document analysis, the following word captures the

main force that drives the process: strategy. Therefore I chose the following statement, which was documented in Chapter 6, to answer this question.

- *Having an alignment between portfolio management of research projects and the organizational strategy and/or program strategy can be beneficial to the organizations.*

The next research question, "How do organizations select which research projects should make up their company's project portfolio?" initially assumed the use of formal methods. However it was found that formal and informal methods are a good mix to support this method. Furthermore, it is important to put the selection process in context as being part of a bigger system. This question was addressed through the following findings:

- *Project selection is benefited by combining both strategic methods and the decision maker's experience.*
- *Portfolio management of research projects is a process of which boundaries go further than project selection.*

Finally, the questions "How do public and private organizations define success in research projects? What drives the difference across firms, if any?" are related to the last part of the PMRP process, project termination. They are addressed through the following findings:

- *Project success depends on the perspective from which it is measured.*
- *Knowledge, the most basic outcome of research projects, is of importance in both private and public organizations.*

While it was possible to address the research questions, there were some limitations associated with this thesis. The main one derived from the amount of time destined to it, one academic semester. Due to this, the number of organizations studied was limited to three; one public organization and two private organizations. Even though the sample is not representative to completely understand the process, it provided an opportunity to model the practicality of portfolio management in these settings.

Another limitation derives from the nature of research methods. Replies from the interviewees depend on their subjective perception of reality and based on their

experience. This, far from been experienced as a limitation, was an opportunity to enrich the interview process through the experience of the interviewees by digging further into their responses and shifting the focus of the interview to cover other areas of interest.

Finally, two of the interviews were conducted by phone; this restricted interaction with the interviewees could be perceived as a limitation to the interview process. However, the long distance issue was addressed by having early communication with the interviewees through e-mail which included communicating the background of the investigation and the interview guide so that they became acquainted with the project before conducting the interview.

Personally, I tried to address these limitations with an open mind and complete disposition from my part to turn them into learning opportunities. I consider this master thesis as one of the most enriching experiences from my academic life. I am particularly satisfied with having found a topic of great interest in the area or project management. Not only is portfolio management of research projects interesting to the academia, but also to the government and the industry. Moreover, its importance is in constant rise due to the dynamic environment faced by these sectors and research projects represent an alternative to respond to this dynamism.

The more organizations rely on research projects, the need to arrange them in portfolio increases and, therefore, the need to understand how to manage such portfolios. This confirms the importance of the topic and sustains the relevance of this thesis, for which I feel rewarded and satisfied.

Finally I would like to present some areas of opportunity for future research. These suggestions were reached through personal reflections while processing the information in this thesis. Hopefully the work at hand can be used as a stepping stone for future studies on these topics. The topics of interest are presented followed by a brief description of their context; this can lead to formulate new research questions in the future:

- *The relationship between the maturity level of the organization and the implementation and execution of the PMRP process.*

Organizational maturity level may affect the implementation of the PMRP process. Mature stable organizations have well defined processes and a clear strategy. Therefore, PMRP has

a reference point to turn to when changes are needed. However, dependence on a formal process or strategy could derive in rigidity and inability of the process to respond quickly to the environmental changes. On the other hand, new organizations have unclear processes and a dynamic strategy, which makes it difficult for the PMRP to rely on them; nevertheless they can provide flexibility in dynamic environments.

- *The role of different actors involved in implementing and executing the PMRP process.*

Implementing a process such as PMRP requires the involvement of top managers, research managers, project managers and researchers. They play roles in every step of the process: defining the business and the research strategies; spreading the important of the process across the firm; implementing the research strategy; conveying the results; planning, control and execution of the process; and even doing the research itself. Some actors play parts in more than one activity and most of their roles overlap.

- *The importance of private and public collaboration in performing research projects.*

Public organizations play two roles in government research. On one side they help set the research strategy that should be followed. On the other side, they perform or fund research projects according to this strategy. In some cases, public organizations perform research themselves; however, in other cases – such as the one presented here – they fund private researchers, institutions and universities to perform the research they have stated as strategic. If a private firm monopolizes very important knowledge, such as the development of a new drug, it could become a serious obstacle to the future progress of human science and bio-technology, and for the development of important industries such as the medical and agricultural industries, which could result in large losses of worldwide welfare. Therefore, there must be a delicate balance between these two sectors that depend on each other to perform research projects and benefit from them.

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Appendix

A1. Interview Guide

Portfolio Management of Research Projects - Interview

Portfolio Management process
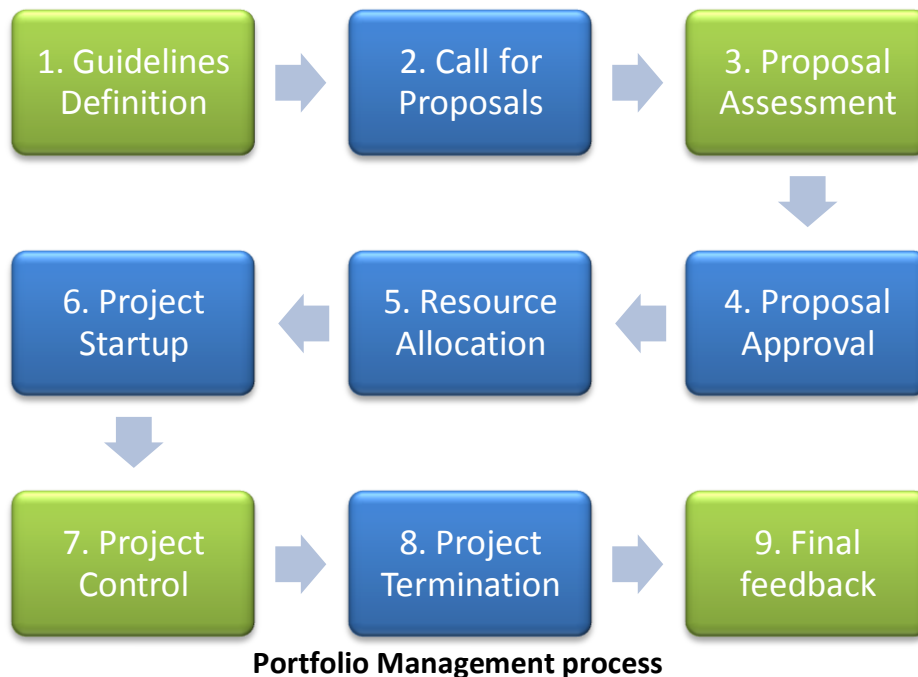
Note: Green boxes represent focus areas/processes for this interview

Company background:

- Name:
- Industry:
- Background

Interview Partner:

- Name:
- Position:
- Years of experience:

Strategic guidelines

- Who defines the strategic guidelines of the institution regarding which research projects should be given priority?
    - *Government, Nation's strategists (Public)*
    - *Upper Management, stakeholders, shareholders, Research Manager (Private)*

- How are these strategic guidelines of the company defined? What factors affect their definition?
    - *Market/Industry needs*
    - *Technology/Scientific development*
    - *Social/Political Changes*
- Do these guidelines change over time? If yes, how often and why? If no, why?
    - *Long term goals?*
    - *Policies?*

Proposal Assessment

- Who defines the guidelines for project evaluation/assessment?

- How are the guidelines defined? What factors affect their definition?

- How do you conduct the process? Who is involved in the process?

- What are the main challenges faced when evaluating the project proposals?

- How are these challenges overcome? And how do you think they could be overcome?

- What happens to good projects that are not selected?

    - *Are they reconsidered for the future? Reshaped? Dismissed?*

- How long is the process from guidelines definition to project approval and start up?

Project Control and Feedback

- How does the institution follow up on project progress? Do you apply any control measurements/mechanisms?

- Are there any challenges associated with the follow up?

- How are these overcome? Any suggestions on how they could be overcome otherwise?

- How do you define project success?

- What happens if a project is not successful?

- How is final feedback reported to decision makers? (i.e. going from process 9 back to 1 in the diagram)