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# Selecting the right projects within an effective project selection method – A multiple case study in the Dutch high-tech industry

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Master Thesis

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## ABSTRACT

The purpose of this research was to improve the understanding of project selection methods to help guide managers in the high-tech industry how to create the most effective project selection method, and to what extent the difference between radical, really new and incremental innovations influences that process. This explorative research was conducted through a multiple case study, in which managers from Dutch high-tech firms were interviewed. Current project selection practices within different high-tech firms are benchmarked in terms of effectiveness and there is investigated which characteristics of their project selection methods influences the four goals of effectiveness: (1) strategic alignment of portfolio, (2) maximize value of portfolio, (3) balanced portfolio, and (4) right number of projects in portfolio. This resulted in multiple discovered relationships, such as that rational and intuitive decision-making are complementary to each other and using this combination positively influences a project selection method's effectiveness. Furthermore, a diverse group who has the decision-making authority and interdependent assessment contribute to effectiveness. And, the innovativeness of new product ideas has a moderating effect on the relationship between some characteristics and effectiveness. This research provides a new perspective on the effectiveness of project selection in the Dutch high-tech industry. Additionally, defining a business strategy, the type of a corporate strategy and knowledge about a firm's current state of affairs were highlighted as important factors for an effective project selection method.

**Key words:** high-tech firms, project portfolio management, project selection method, tools/techniques, effectiveness, decision-making, idea assessment, rationality, intuition, decision criteria

## **PREFACE**

Hereby I present my Master Thesis “Selecting the right innovation projects with an effective project selection method – A multiple case study in the Dutch high-tech industry”. This research is the final activity for the master’s degree in Business Administration specialization Innovation & Entrepreneurship at the Radboud University in Nijmegen.

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In addition, I would also like to thank all firms, especially the informants, for their cooperation in this research and the interesting stories they told me during the interviews. And finally, of course I want to thank my family and friends for supporting me during the last, stressful half-year of my studies.

I hope you enjoy reading my Master Thesis!

Milou Hemel

Borculo, August 2018

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## 1. INTRODUCTION

Nowadays, in a world of global competition, innovation has become increasingly important for firms to survive. Innovation is basically the key driver for long-term success. But, innovation projects are often not successful. New product success rates stay low (Killen et al., 2008). Unsuccessful innovation projects in high-tech firms increases pressure on the resources.

The managing of single projects is no longer sufficient in today's business, because many firms employ multiple projects. As a result, projects often have to 'compete' with other projects for scarce resources such as money, people, time and knowledge. It is a great challenge for innovation managers to assure that R&D budgets are allocated to the best optimal set of R&D projects in order to reach their innovation targets (Vandaele & Decouttere, 2013). For the achievement of long-term success and competitive advantage, an effective management of the project portfolio has become more important (Heising, 2012). However, that is not easy. The increasing complexity of multiple technologies for shortening product life cycles, forces high-tech firms to rely on good R&D management (Mikkola, 2001). Therefore, according to Jonas (2010), Project Portfolio Management (PPM) is becoming a key factor for firms managing multiple projects simultaneously. Based on Cooper et al. (1997), Martinsuo (2013, p. 794) describes PPM as follows: "PPM deals with the coordination and control of multiple projects pursuing the same strategic goals and competing for the same resources, whereby managers prioritize among projects to achieve strategic benefits". The selection of the right projects is a big and important part of PPM. Usually, there are more innovation ideas available than the firm's ability to further develop these as projects, as a result of physical and financial constraints. Unfortunately, too often, the process of project selection fails (Ghapanchi et al., 2012), which means that the chosen innovation projects became unsuccessful or not successful enough as expected before the selection, due to complexity in PPM. This complexity can arise by many underlying factors, such as uncertainties and risks of projects, the interaction between multiple projects, changes over time, opposing interests and success factors that are hard to measure (Coldrick et al., 2005).

An example of a firm in the high-tech industry who faces these challenges is Bo-flow. Bo-flow develops, manufactures and markets high quality products for mass flow and pressure measurement and control for many different markets and applications. The Bo-flow management team is responsible for the selection of those innovation projects from the six product design teams which benefit most to the development of the overall Bo-flow project portfolio and assign an appropriate amount of resources, both capital and human, to these projects. Herefore, an optimal decision-making process of the selection of projects may require both rationality and intuition (Calabretta et al., 2016; Elbanna & Child, 2007). The problem that the management of Bo-flow, but also other firms, faces is that the decision-making process for project selection is often only based on intuition, which means that decisions are made based upon managers' experiences and feelings (Kumar et al., 2009). Martinsuo (2013) suggests the opposite and considers PPM only as a rational decision-making process.

Looking at an effective method for project selection, taken into account different types of project selection, will increase the chances of successful innovation projects (Calabretta et al., 2016; Elbanna & Child, 2007). Hence it is desirable to develop a method that assists the management of a high-tech firm and enables to create the best possible product portfolio by

using an effective project selection method. In addition, most high-tech firms have to decide in which balance they develop projects with a different degree of innovativeness. Radical innovations are often described as disruptive or breakthrough innovation, which implies taking a significantly new road (Henderson & Clark, 1990). The costs and risks for developing such radical projects are usually higher than the costs and risks of incremental projects, which refers to small changes in a product or service. As a result, this innovativeness of new product ideas influences the process of project selection. To date, academic knowledge lacks on an effective project selection method in the high-tech industry, which includes both rational and intuitive decision-making, and takes the innovativeness of new product ideas into account. “Effective project portfolio management is one of the key factors determining the success of any business”, (Nowak, 2013, p. 821). But what is meant by effectiveness? Keh et al. (2006) define effectiveness as doing the right things in order to maximize the level of output. Concretely, this can be seen as achieving the four PPM goals developed by Cooper et al. (2001): (1) make sure that the portfolio is aligned with strategy, (2) maximize value of the portfolio, (3) achieving a balanced portfolio, and (4) pick the right number of projects.

### **1.1 Research objective and question**

This research aims to improve the understanding of project selection methods to help guide managers in the high-tech industry to choose and create the most effective project selection method, and to what extent the difference between radical, really new and incremental innovations influences that process. The research question to achieve this objective is formulated as follows: *Which type of project portfolio selection method of an high-tech firm is effective when the innovativeness of new product ideas is taken into account?*

To answer this research question sufficiently, the following sub-questions will be answered consecutively.

1. What is the current state of project selection methods and practices described in the literature that can be used for creating an effective method?
2. What are the current practices in different high-tech firms concerning their project selection in terms of effectiveness?
3. How are different characteristics of project selection methods related to effectiveness in different high-tech firms?
4. How does the difference between radical, really new and incremental product innovation influence the effectiveness of project selection methods?

### **1.2 Academic relevance**

While progress has been made in literature in the pursuit of a process approach to achieve effective PPM, limited insight has been provided into an effective project selection method in the high-tech industry in the Netherlands. The high-tech industry is one of the nine top sectors designated by the Rutte-Verhagen government (Rijksoverheid, 2011). This industry differs from the other sectors in its R&D intensity. At high-tech firms, R&D spending is relatively high compared to firms from other sectors. "The top sector invests around €2.2 billion in R&D on an annual basis, accounting for almost half of the total private R&D of our country", (Topteam HTSM, 2011). Last year, CBS (2017) also finds that the high-tech industry sector has the far most R&D expenses. A figure is shown in Appendix 1. This means that a lot new

R&D knowledge is gained at high-tech firms that is converted into many project proposals, which makes it very hard for high-tech firms compared with other firms, to select the right projects within their portfolio. “In-depth case study research could help to improve understanding and develop capability in methods to link long-term strategy and vision with current operations”, (Killen et al., 2008, p. 34). Archer & Ghasemzadeh (1999) suggest that further research is needed into determining which modelling techniques are preferred by managers and decision-makers, in order to simplify them to make them more useful and acceptable. Besides, there is literature known about PPM’s practices and researchers describe PPM as a method to achieve an effective project portfolio, e.g. Cooper et al. (1999), Martinsuo (2013), Muller et al. (2008), Killen et al. (2008). However, future analysis should take contextual factors, such as industries and the type of method/tool used for PPM, into account (Jonas, 2010). Looking at a particular context, such as the high-tech manufacturing industry, has been underexposed. In the high-tech industry, the R&D department is often the key center of the firm, because of the need to develop successful new products continuously, so that high-tech firms can survive and compete in their rapidly changing market (Verma et al., 2011). The resources they have at their disposal are largely used for the development of new products. This involves a lot of money, which is why selecting the most optimal projects is so important for these high-tech firms and why the effectiveness of a project selection method is significant.

### **1.3 Managerial relevance**

Kumar et al. (2009) discovered in their research that the decision-making process of project selection in many firms is based on managers' gut feeling. The knowhow on an effective project selection method, based on a sustainable resource allocation in which both the rational and intuitive factors are taking into account, is new for Bo-flow managers and other high-tech firms. They would like to know whether a more rational approach would be more effective and which characteristics of project selection would contribute to this. High-tech firms have a lack of knowledge about the choice and creation of an effective project selection method. The results of this study will acquire knowledge that can be helpful for firms in the high-tech industry, for entering various improvements in the management decisions to attain an effective project selection method to achieve their innovative targets.

### **1.4 Scope**

PPM consists of two different parts; (1) project portfolio selection and (2) the management of a portfolio (Patanakul et al., 2013). This research focuses on the first part, namely project portfolio selection. The management of the selected portfolio is left out of consideration.

### **1.5 Research outline**

This research consists of six chapters. In this first chapter, the problem, purpose, research questions, relevance and scope of this research have been introduced. In the second chapter, the literature review is mapped and analysed in order to give an answer on sub-question 1. The third chapter presents the methodology. The fourth chapter concerns the results in order to answer the research question. Chapter five deals with the conclusion and chapter six with the discussion which includes theoretical implications, managerial implications, limitations and recommendations for further research.

## 2. LITERATURE REVIEW

The topics which are discussed in this research are also occurred in previous studies. This chapter gives an insight into the topics and definitions which are used during this study. It is important to view the topics of interest related to this research from existing academic researches to understand the position of this research in the bigger picture, so that this research is original and contributes to the existing literature.

### 2.1 Innovation and New Product Development

Innovation is the process of translating a new idea into a product or service, but also into firm processes and methods or devices (Brown, 1992). It is about ‘newness’. Van de Ven (1986, p. 591) defines innovation as follows: “a new idea, which may be a recombination of old ideas, a scheme that challenges the present order, a formula, or a unique approach.” However, when other people think that a new idea is imitation, it also must be treated as innovation because of the newness (Gupta et al., 2007). All this can be summarized in the concept ‘innovation’, defined as the implementation of an evolved idea – concerning a product, process, system, program, device, or service – that is new to the firm at the time the idea was adopted (Damanpour & Evan, 1984; Zaltman et al, 1974).

This is still a very broad definition, which is simply and easily understandable, but research on innovation show that it is complex. One reason for that complexity is that the concept innovation often overlaps with other concepts, such as imitation, change, invention, as described above. A second reason is that firms can both create and adopt an innovation. It can be a completely new idea generated by the firm, but it can also be an idea of someone other who will be used by the firm. New ideas came from different people, such as employees and customers. In this research, no distinction is made between them and an idea can arise from both outside the organization and within the organization. The last reason for complexity of the concept ‘innovation’ is that there are different types of innovation. Many researchers do not distinguish between those types and mention only innovation, but to understand innovation in this research it is important to know which type will be investigated.

In the literature, different types of innovations are emphasized; product innovation and process innovation (Utterback & Abernathy, 1975), organizational innovation (Crossan & Apaydin, 2010; Boer & During, 2001; Cozzarin, 2017), and service innovation (Den Hertog et al., 2009). Product innovation is basically a new technology or new technology components developed in order to meet a customer need, while process innovation focuses on efficiency improvements of the production process, to achieve cost-minimizing and/or more speed (Utterback & Abernathy, 1975). Cozzarin (2017) argues that organizational innovation encompasses new business practices, workplaces, but also internal and external relationships, such as human resources, partners or alliances. New forms of division of labour and task coordination belong also to organizational innovation (Makó et al., 2013). Last decades, service innovation has been a topic of growing interest among researchers. Services are, compared to products, intangible and often co-produced with customers, for example retailing, educational courses, consulting, traveling, etc. Den Hertog et al. (2009) defines service innovation as follows: “A service innovation is a new service experience or service solution that consists of one or several of the following dimensions: new service concept, new customer interaction, new value system, new revenue model, new organizational or technological service delivery system” (p. 494).

To eliminate the complexity of the concept ‘innovation’, in this research innovation means the implementation of a new idea, generated from outside or inside the firm, which is based on products. Because the purpose of this research is to improve the understanding of project selection methods, which is about selecting new projects to the portfolio of a firm, and these projects are all about products. Thus, innovation in this research is product innovation.

In addition, innovation can be studied at different levels of analysis, such as the individual level, group/team level, organizational level and level of industries (Gupta et al., 2007), whereas the organizational level is the most suitable level of analysis for this study. The organizational level deals with technological innovation and the development of new products and/or new product lines. This can also be seen as the concept ‘New Product Development’ (NPD), which is only concerned with bringing a new product on the market, and not with other new developments regarding processes and methods. Kotler & Armstrong (2004, p. 397) define NPD as “the development of original products, product improvements, product modifications and new brands through the firm’s own R&D effort.” It covers basically the whole process from a new idea till the launch of a new product on the market. Consistent with all of these definitions and interpretations of innovation, in this research, innovation is based upon projects that consist of developing new products and improving or adapting existing products. Many firms have to deal with different products and product groups. As a result, such firms have multiple (development) projects and therefore, they need to manage a project portfolio. This will be explained in section 2.2.

### ***2.1.1 Innovativeness of new product ideas***

Last decades, researchers have defined the concept ‘innovativeness’ in different terms. Utterback (n.d.) distinguished innovativeness of new product ideas in discontinuous change or radical innovation and continuous change or incremental innovation. According to him, radical innovation introduces discontinuity at the firm level, while incremental innovation demonstrates standardization within a firm. However, this is very vague. Because what types of innovations are covered?

Other researchers used their own definitions, for example the following. Radical product innovation is a product that has high newness of technology and high customer-need fulfilment, while incremental product innovation scores low on both aspects (Sorescu et al., 2003). Radical product innovation often creates whole new markets because of revolutionary changes, where the opposite of revolutionary changes are minor changes or adjustments in existing products which is labelled as incremental product innovation (Dewar & Dutton, 1986). Henderson & Clark (1990) claim that radical product innovation force firms to ask new questions and develop new skills, while incremental product innovation strengthens the existing capabilities of firms.

What becomes clear from this, is that the big difference between radical and incremental product innovation is the degree of newness in technologies and in knowledge. But Garcia & Calantone (2002) criticized this is still too unclear, because from whose perspective is this degree of newness viewed and what is especially new? Garcia & Calantone (2002) define product innovativeness as “a measure of the potential discontinuity a product can generate in the marketing and/or technological process” (p. 113). They approach innovativeness from two perspectives; a macro perspective based on a shift in a specific industry, and a micro

perspective based on an influence in the firm's existing resources and capabilities. In the end of their study they did not only make a distinction between radical and incremental, but added a middle way category, namely the 'really new' innovations. Kleinschmidt and Cooper (1991) also made a distinction into three categories; high, moderate and low innovativeness. They define products with high innovativeness as new to the world and/or new to the firm, and low innovative products as modifications, cost reductions and repositioning's. Moderately innovative products are new products in existing lines and less innovative new lines (Kleinschmidt and Cooper, 1991). But when is something less innovative? Due to this lack of conformance in distinguishing the three categories, this research uses the three clearly demarcated categories of Garcia & Calantone (2002) and define them as follows. Radical product innovations are new products that comprise a new technology that cause a new market structure, incremental product innovations are new features and improvements in existing technologies in the existing market, and really new product innovations falls in between with new products that include a new technology or create a new market structure (Garcia & Calantone, 2002).

## **2.2 Project Portfolio Management**

Most firms face a resource crunch; a significant gap between required resources and the available resources. A solution for overcoming this problem, is make use of Project Portfolio Management. Cooper & Edgett (2003) argues that the resource crunch is not a result of a lack of resources, but it is more about the "how". How are the resources allocated? How should a firm, in the most effective way, invests its R&D resources? That is what PPM is all about. The facilitation of these questions concerning resource allocation among project proposals is one of the main objectives of PPM. In the existing literature, researchers use a different definition of PPM, but eventually, they all come down to the same thing. Cooper et al. (1997, p. 17) define PPM as a dynamic decision process, "whereby a business's list of active new product (and R&D) projects is constantly up-dated and revised. In this process, new projects are evaluated, selected and prioritized; existing projects may be accelerated and re-allocated to the active projects."

Martinsuo (2012, p. 794) writes the definition of Cooper et al. (1997, p. 17) in her own words as follows: "PPM deals with the coordination and control of multiple projects pursuing the same strategic goals and competing for the same resources, whereby managers prioritize among projects to achieve strategic benefits". It says basically the same as the definition drawn up by Cooper. Heising (2012, p. 584) formulates PPM as "the simultaneous management of the collection of projects that make up an investment strategy of a company". And Kester et al. (2011, p. 641) define PPM as "the set of activities that allows a firm to select, develop, and commercialize a pipeline of new products aligned with the firm's strategy that will enable it to continue to grow profitably over the long term".

The definition of Heising (2012) includes the management of projects, while in this study the focus is on the selection of projects. Kester et al. (2011) include firm performance as a PPM goal, and eventually that is right, but the direct goals of PPM are different, described in the following section. This study focuses on the direct goals, in terms of effectiveness, of PPM. The definition written by Kester et al. (2011) indicates confusion. The definition written by Cooper et al. (1997) is a concrete definition that reflects in detail what PPM entails. PPM is a

management tool, whereby the decision-making process plays a major role, and this definition clearly emphasizes that. Besides, Robert G. Cooper is, globally, seen as one of the most influential innovation researchers today. He investigated the phenomenon 'PPM' several times within different contexts. His definition is the most detailed, emphasizes the decision-making process and the constantly updating activity of new project proposals.

These are the reasons why the following definition written by Cooper et al. (1997, p. 17) is used in this research: "PPM is a dynamic decision process, whereby a business's list of active new product (and R&D) projects is constantly up-dated and revised. In this process, new projects are evaluated, selected and prioritized; existing projects may be accelerated and re-allocated to the active projects."

### ***2.2.1 Related concepts***

In the literature, the concept of PPM appears in several ways. Besides Project Portfolio Management, there are more related concepts. The most common are Project Management, Programme Management, Pipeline Management and Multi-Project Management. Even though these related concepts focus on similar aspects, they also show some quite important differences. By understanding each concept and the differences between them, the position of PPM in the current literature can be better understood.

In Project Management, projects are defined by sets of coordinated human activities who pursue the same objective (Bennett, 2006). The coordination, decision-making and control of each project belongs to the managing part. This is different from PPM, because Project Management focuses on managing and developing one project independently.

According to Ferns (1991) and Gray (1997) Programme Management is a mechanism or tool for directing and coordinating projects that are related to each other with the intent of attaining benefits. These benefits cannot be realized when they are independently managed (Lycett et al., 2004). This concept is at the same level as PPM, but is different in the main purpose. The main purpose of Programme Management is creating a higher value than the sum of the individual projects together with more focus on the dependencies among projects. In PPM, projects are also related often, but the dependencies are left out of consideration.

The next common concept which is widely used in the literature is Pipeline Management. "Pipelines are characterized by a flow of projects through various stages of a process; some projects are eliminated in selection processes, while others may successfully be accomplished," (Söhnchen & Albers, 2010, p. 1356). Compared to PPM, this concept is more about daily activities related to the allocation of available resources during different stages in the new product development process. Therefore, Pipeline Management can be considered as a link between PPM and the daily management of product development activities.

The primary theme of Multi-Project Management is the question of how to allocate resources between simultaneous projects (Payne, 1995; Clark & Wheelwright, 1992). Engwall & Jerbrant (2003) describe a multi-project environment as various projects developed parallel, making some use of the same resources. This concept is close to PPM, except that the focus in Multi-Project Management is more on resource allocation (De Maio et al., 1994) and less on predicting the future profitability of each project, which in case PPM takes into account. PPM helps a firm select which projects they should develop further, whereas Multi-Project Management assists a firm accomplish the selected projects in an efficient and time effective

manner. Thus, PPM focuses more on alignment with the strategy of the firm (top-down), whereby Multi-Project Management more looks at the available resources (bottom-up). The level is the same, but the intention of managing projects is different (De Maio et al., 1994). Based on the descriptions of each concept, figure 1 has been drawn up to show the positioning of PPM related to other concepts in the current literature. The figure clearly shows that PPM is close to the strategy of a firm, which corresponds to one of the four goals of Cooper & Edgett (2001) about the alignment with strategy.

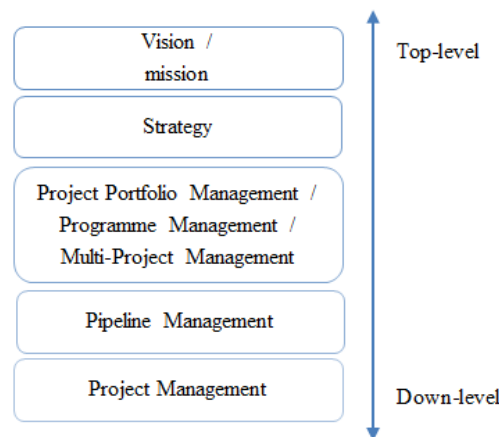


Figure 1: A visualisation of the position of PPM related to other concepts

### 2.2.2 The four goals of PPM

The direct goals of PPM are based on four areas of high importance in managing R&D activities. Cooper et al. (2001) state the following four direct goals of PPM: (1) maximize value of the portfolio, (2) achieving a balanced portfolio, (3) make sure that the portfolio is aligned with strategy and (4) pick the right number of projects (e.g. Kester et al., 2011; Heising, 2012; Martinsuo, 2013; Jonas, 2010; Patanakul, 2015).

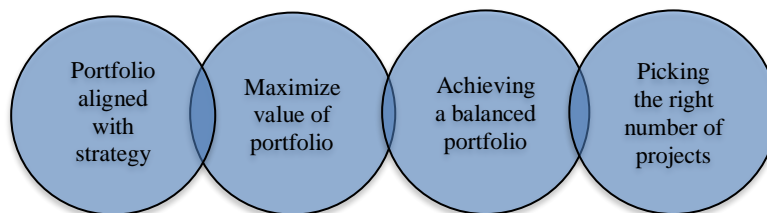


Figure 2: The goals of PPM (Cooper & Edgett, 2001)

The first goal indicates that the portfolio must be aligned with the firms' strategy (Cooper et al., 2001). This goal takes into consideration the strategic fit between the portfolio and the business strategy of a specific firm, and aims at selecting only those projects that are aligned with the business strategy. For example, when a firm's strategy is to focus on certain industries or technologies, then the projects should also be focuses on such industries and technologies, or when a strategic goal of a firm is to enter a new market, then they must have projects that can realize that. A firm's business strategy indicates the way a firm determines how to compete in the market in comparison to its competitors (Varadarajan and Clark, 1994). This is different from a corporate strategy which is concerned with choices about what business to compete in

(Beard & Dess, 1981). Shenhar et al. (2001) argue that the project portfolio of a firm can be a “powerful strategic weapon”, to help a firm implementing and executing its strategic direction (Dietrich & Lehtonen, 2005). That is why the ultimate purpose of a strategic aligned portfolio is to establish a plan that will support the firm in achieving its objectives (Hyväri, 2014). Many researchers support Cooper’s argument that strategic alignment lead to better firm performance, e.g. Chesbrough (2002), Bergeron et al. (2004), Lin & Lee (2011) and Zatzick et al. (2012).

The second goal, maximizing the value of the portfolio, is about selecting new innovation projects in a way to maximize the commercial value of the portfolio (Cooper et al., 2001). In other words, the degree to which a firm tries to predict the expected project values and select projects with an high expected value is a way to maximize the portfolio value (Patanakul, 2015). Because of maximizing the commercial value, this goal only takes into consideration financial aspects. Firms exist to create profit and survive in an heavily changing environment. Projects with high expected return are therefore an important tool to earn profit.

The third goal is about achieving a balanced portfolio in terms of different parameters (Kester et al., 2014; Cooper et al., 2001); such as short-term and long-term projects, different markets, and different levels of innovativeness; which is the parameter this research focuses on. But also taking into consideration parameters such as different project sizes and time frames. When a project portfolio is ‘in balance’, this means that the portfolio is harmonious and takes different types of projects into account (Kester et al., 2014). Cooper et al. (2001) define a balanced project portfolio as an optimal spread of risk in projects. For example, when a firm develop all projects for exactly the same market, and that market is no longer profitable due to a shift in the needs of customers, this firm has invested a lot of money in projects that ultimately all fail. So, the overall firm risk was not spread in a good way. Patanakul (2001) describes this as being adaptable to internal and external changes. Mikkola (2001) summarizes all these descriptions in one clear definition of a balanced portfolio: a mixed combination of projects that spreads the firm’s overall risk, while trying to achieve the growth and profit objectives linked with the strategy. However, the ideal portfolio balance is different for each firm, because this balance depends on a firm’s strategy, and on the complexity and turbulence of the environment (Chao & Kavadias, 2008).

And the last goal stands for picking the right number of projects based on the available resources (Cooper et al., 2001). Most firms have too many innovation proposals, but limited resources available. In other words, firms have a lot to do with resource constraints. Firms must, besides achieving the previous three goals, always be aware of whether they have enough resources to select certain projects (Cooper et al., 2001). Picking the right number of projects, not too many, to develop further is therefore very important to deal with the resource crunch. Not only the number of resources is important in this case, but also the type of resources. Does a firm, for example, have employees available with the right knowledge for a project?

Kester et al. (2014) find empirical support for a positive relationship between the achievement of these PPM goals and firm performance. Each goal play a different role in helping firms to achieve better performance, so each one is important in its own way.

### 2.3 Project portfolio effectiveness

Most researchers take a methodological perspective on an effective project portfolio, by focusing on calculation methods and algorithms for optimizing projects (e.g. Henriksen & Traynor, 1999; Doerner et al., 2006). However, effective project management of a single project is no longer adequate. Nowadays, the management of the whole project portfolio has become a vital factor for achieving long-term success and competitive advantage (Heising, 2012). That is why it is not necessary to look at effective NPD, but at an effective portfolio.

Jonas (2010) uses an high average project success, use of synergies, strategic fit and portfolio balance as success factors for portfolio success. Patanakul et al. (2013, p. 32) define PPM effectiveness as follows: “The organizational capability to form and govern a project portfolio such that the portfolio aligns with the organization’s strategic direction, addresses risks and opportunities, and is adaptive to the internal and external changes in order to provide short and long-term value of benefits to the organization”. However, Cooper et al. (1997, 2001, 2003) and Kester et al. (2014) find four important characteristics of successful NPD portfolios and claim that these are the criteria for an effective PPM: (1) strategic alignment, (2) maximal portfolio value and (3) balanced portfolio and (4) right number of projects, which correspond to the goals of PPM described in the previous section.

In each definition described above, the strategic alignment and maximizing the value of a portfolio come forward. Jonas (2010) also defines effectiveness as a portfolio balance. Thus, the four goals of Cooper et al. (2001) are the most overarching and obvious dimensions of ‘effectiveness’. Therefore, the effectiveness will be examined in this research in terms of meeting the four goals of Cooper et al. (2001) for creating an effective portfolio.

In this research, it is expected that the innovativeness of new product ideas has a moderating effect on the relation between type of project selection methods and effectiveness. In other words, for radical product innovation it is expected that another type of project selection method is effective than for an really new and/or incremental product innovation. But why is that expected? Radical product innovations are associated with high levels of uncertainty, unpredictability, unplanned outcomes and serendipity (O’Conner & Rice, 2013; Colombo et al., 2017). That is why radical product innovations are difficult to evaluate or predict for selecting the right projects. It is easier to create a better prediction of incremental product innovations. This means that the radical projects cannot be properly compared with incremental projects, because the evaluation and predictability is not equivalent, and so the selection process is expected to differ for each level of innovativeness. This will lead to the following overall conceptual model:

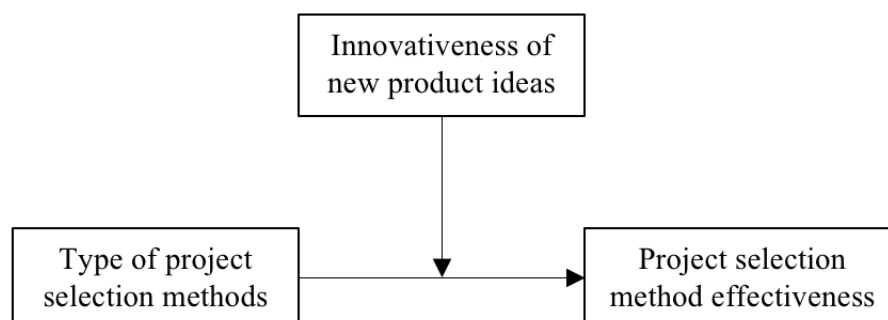


Figure 3: Overall conceptual model of this research

A 'type' of project selection method is concretely a specific combination of different characteristics. But the question that plays a role here is; which characteristics together form a type of project selection method that can be considered as most effective? The underlying relationships between characteristics of project selection methods and the effectiveness of these methods have been under investigated. The relationships between different characteristics and the four goals of effectiveness will be examined in depth. This is further explained in the remainder of this chapter.

#### **2.4 Project selection as a complex decision-making process**

First of all, what is meant by a decision-making process regarding project selection? It is the process of making choices by identifying a decision, gathering information, assessing new product ideas, weighting the criteria and choose among the alternatives (Hussung, 2017). Within PPM there is a continuous flow of decisions that have to be made. PPM consists of two different parts; (1) project portfolio selection and (2) the management of a portfolio (Patanakul et al., 2013). This research focuses on the first part, on the task of choosing and selecting new product ideas to develop further as a project to add it in a firm's product portfolio, and so decisions must be made about which new product ideas are selected as projects or rejected. Archer & Ghasemzadeh (1999, p. 208) define project portfolio selection as follows: "The periodic activity involved in selecting a portfolio, from available project proposals and projects currently underway, that meets the firm's stated objectives in a desirable manner without exceeding available resources or violating other constraints." The decision-making process of project selection is dynamic, because of the multiple and interrelated decisions that must be made in a continuously changing environment (Gonzalez, 2005). The changes in the environment can be caused by previous actions of the decision makers or due to other events which have an influence on project selection. This is why project selection is seen as a complex decision-making process.

Archer & Ghasemzadeh (1999) encountered a lack for an integrated framework with distinct stages for carrying this decision-making process out. This method is mainly based on the decision-making process of project selection and shows various steps that firms can follow. Archer & Ghasemzadeh (1999) distinguish 3 consecutive phases in this decision-making process: (1) strategic considerations, (2) individual project evaluation, and (3) portfolio selection. These phases are quite similar to the goals of PPM. There exist various complexities in project portfolio decisions. A lot of criteria need to be taken into account by making trade-offs among different project proposals, which are often seen as quite difficult. This difficulty is the reason why many managers make decisions based on their intuition. However, the risks, probability of successes, strategic fit and profitability must be taken into account before a decision is made. Also the interdependencies among projects is an important factor. As a result of all the complexities involved in project portfolio decisions, Archer & Ghasemzadeh (1999) developed the following framework for making decisions in different stages each with its own objective.

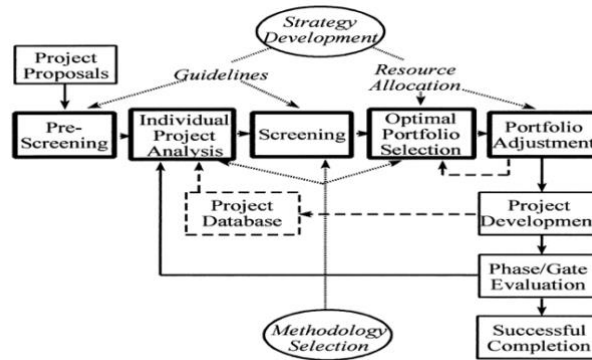


Figure 4: Framework for Project Portfolio Selection (Archer & Ghasemzadeh, 1999)

This framework is in fact a model to simplify and organize the decision-making process of project portfolio selection. Benko & McFarlan (2003) present also a framework and related tools for coordinating a firm’s project portfolio. They also include steps for projects aligning with the overall firm’s strategy. But the framework of Archer & Ghasemzadeh (1999) has been used more often in researches and gives a brighter overview of the steps that belong to the decision-making process., e.g. Martinsuo (2013), Kaiser et al. (2015), and Patanakul (2015). In this research, the decision-making process of project selection is defined in the context of Archer & Ghasemzadeh (1999), from project proposals to optimal portfolio selection. Gathering information to assess and compare new product ideas, for making the right choices, is of great importance in project selection (Chien, 2002). That is why it is considered being part of the decision-making process in this study. The development of the selected projects and the management of the portfolio is not included in this study, as has been described earlier.

Besides, Kester et al. (2011) developed also a model for portfolio decision-making processes, not based on stages, but on evaluating portfolio decision-making effectiveness. The objective of this model is to attain decisions of high-quality concerning PPM (Kester et al., 2011). This model show three different cultural factors that impact the decision input, which in turn influence the portfolio decision-making process and its effectiveness (figure 5).

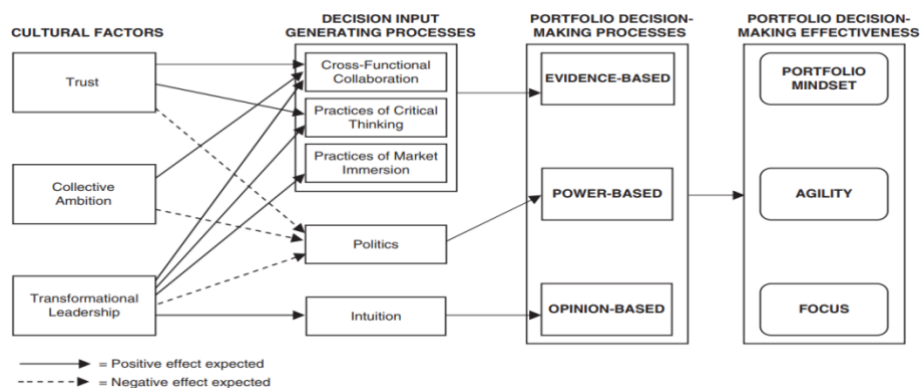


Figure 5: Model of portfolio decision-making (Kester et al., 2011)

Kester et al. (2011) distinguish three different decision-making approaches: rational, political and intuitive decision-making, which are consecutively related to evidence-based, power-based and opinion-based decision-making. In evidence-based decision-making firms make use of

empirical evidence and objective information for a good substantiation when selecting projects (Kester et al., 2011). Before new product ideas are selected as projects, the decision-makers ask employees from across multiple functions about the assumptions underlying the evidence. So several people with different job functions are involved in making evidence-based decisions. The goal in this approach is to build an objective rationale (Kester et al., 2011). Power-based decision-making is not based on evidence, but on unequal distribution of power (Kester et al., 2011). This means that some groups or individuals with more power than others, dominate the decision-making process. So no matter what, the powerful people decide and select the projects. In this approach it often happens that the interests of the firm itself are not properly taken into account (Kester et al., 2011). The last one is based on subjectives and is called opinion-based decision-making. This kind of decisions are based on personal interests, experience and gut feeling, rather than on facts (Kester et al., 2011). According to Kester et al. (2011) these three approaches interact with each other so that firms use a combination of evidence-based, power-based and opinion-based decision-making in making decisions about the selection of projects. But what will lead to an effective project selection method depends upon the interactions.

Thus, project selection is a complex decision-making process wherefore Archer & Ghasemzadeh (1999) developed a framework showing the stages of this process a firm can follow. There are many procedures and frameworks developed in the last decades that can act as a guideline in this decision-making process. Researchers use different terms to explain this process about project selection; like a technique, model or method. But, researchers use these terms interchangeably without distinguishing differences. All these terms can be useful in selecting new projects, but to stay consistent, the term 'method' is used. In this research, a method means the decision-making process around project selection, from new product ideas to optimal portfolio selection, in combination with a tool/technique that supports firms in the first three stages in the framework of Archer & Ghasemzadeh (1999); pre-screening, idea assessment and screening. The following paragraph describes the most common examples of such tools/techniques from the literature.

## **2.5 Existing project selection tools/techniques to support decision-making**

Firms select projects in their own way and often make use of certain selection criteria (Kaiser et al., 2015). Throughout the years, different tools/techniques have been developed to assist the decision-making process of project selection. Note that firms can use multiple project selection tools/techniques. These provide insights and guides to managers in the decision-making process of new product idea assessment (Cooper et al., 2001). Different project selection tools/techniques already exist in the literature developed by Cooper et al. (2001), which are described in the next sections.

### ***2.5.1 Financial tools/techniques***

Financial methods are the most common used methods in the decision-making process of project selection. These are understood as financial calculations. Financial methods are basically ways of scoring. Various return and profitability metrics can give an indication in predicting the future, such as Return on Investment (ROI), Net Present Value (NPV), payback period and Expected Commercial Value (ECV) (Cooper et al., 2001). The ECV is determined

for each innovation project and divided by the R&D costs per project. See Appendix 2, figure A, for a visualization of the ECV approach. Loch & Kavadias (2002) argue that firms can use marginal analysis to optimally allocate available resources and developed a dynamic model. Constantino et al. (2015) developed an artificial neural network tool which is able to analyse multiple project critical success factors (CSF's) in order to identify expected returns. When a firm uses a financial method for project selection, the projects are selected and rank ordered based on the metrics.

### ***2.5.2 Firm's strategy tools/techniques***

Firm's strategy tools ensure that the selected projects, and eventually the portfolio, reflect the firm's business strategy which is crucial for success (Kaiser et al., 2015). This means that the firm's business strategy the basis is for allocating the available resources across new innovation projects and it is the second most used method (e.g. Graves et al., 2000; Matheson et al., 1994; Ringuest et al., 1999; Cooper et al., 1999). How does this method work? After deciding the business strategy and the goals that a firm has in mind, different types of projects are selected into different 'buckets'. These buckets can be split in various dimensions, for example by market, by product line or by product type. The next step is ranking the projects within buckets. Researchers and firms also call this method the Strategic Buckets approach (Chao & Kavadias, 2008). Appendix 2, figure B, shows an example of this method. Firm's strategy methods only focus on a fit with the firm's strategy, so other criteria are not included.

### ***2.5.3 Bubble diagrams***

Bubble diagrams are a way to visualize projects and to clarify the differences between projects on any criterion, e.g. risk and reward (Cooper et al., 2001; Matheson & Menke, 1994). Rousset et al. (1991) came up with several other dimensions which can be used on the X and Y axes, such as; strategic alignment, importance, durability of the competitive advantage, technology impact, probability for success, but also costs for development and implementation. The projects are plotted on X and Y axes. Bubble diagrams are popular in displaying the portfolio balance (Augusto & Miguel, 2008). They also give managers the opportunity to see resource implications when adding one new project to the portfolio, another project or projects must pay a price (Cooper et al., 2001). See Appendix 2, figure C, for a particular risk-reward bubble diagram. Another example for such bubble diagram is the BCG matrix developed by the Boston Consulting Group. It is a strategic analysis method that compares relative market share with market growth. You can plot each project of a firm into the matrix to get more insight about the attractiveness of projects and how to allocate resources among them (Campbell et al., 2014). The matrix consists of four areas; stars, dogs, question marks and cash cows. An example is show in Appendix 2, figure D.

### ***2.5.4 Scoring models***

Other methods also make use of 'scoring' projects, but in the literature scoring models are rating tools whereby projects are rated on several questions and/or criteria (Hall & Naudia, 1990; Cooper et al., 2001; Jessop, 2010). Eventually, a total project score will then roll out. These criteria are helpful for managers who have to decide which projects will be selected. Scoring

models do not consider resource implications or portfolio balance, but gives an insight into project attractiveness based on the stated criteria. See Appendix 2, figure E, for an example.

### **2.5.5 Checklists**

Checklists are the least common project selection method and are a variation of the scoring model (Cooper et al., 2001). Using this method will help managers to compare projects with each other. Checklists include a number of yes/no questions. Projects are evaluated on these questions and each project must answer yes to a predefined number of questions to proceed (Cooper et al., 2001). These evaluations are used to make go/kill and ranking decisions. So, checklists are almost similar to scoring models, but instead of assigning a score, the criteria is answered with a yes or no.

## **2.6 Characteristics that distinguish project selection methods**

The previous described existing methods – the project selection decision-making process in combination with a tool/technique – include different characteristics. Distinguishing these different characteristics within the high-tech industry makes it easier to identify which type – a specific combination of different characteristics – is effective and how that is specifically related with the four goals of effectiveness in order to give managers in-depth insights about project selection. In addition, these are probably not the only characteristics that play a role in the selection of projects, but new characteristics can also be emerged from the data collection. The most obvious characteristics that can be obtained from the literature are described below. The described characteristics can be distinguished in three different kind of characteristics: (1) decision-making, (2) scoring and (3) content. Decision-making characteristics are based on the decision-making process. How are the decisions taken and who is taking them? Scoring characteristics are about how projects are assessed and compared with each other in order to support decision-making. Content characteristics focus on the decision criteria itself. In other words, on which criteria are projects assessed and do firms make their choices with regard to project selection?

### **2.6.1 Rational, intuitive and/or political decision-making**

Rationality, intuition and politics are decision-making characteristics elaborated by Kester et al. (2011) and they described these as decision input generating processes. Kester et al. (2011) concluded that rationality, politics and intuition interact with each other. In other words, firms can use a combination of these three in making portfolio decisions. But what exactly do these decision-making characteristics mean and how do they relate to each other?

#### **2.6.1.1 Rationality**

Rationality is a common concept that has been investigated by researchers. There exists no unambiguous definition. Researchers view this concept differently and measure rationality in different ways. When this research talks about rationality, it is only about rationality in the decision-making process; rational decision-making. The word rationality comes from ‘ratio’, which means the reason, a motive, or a motive for an action (Nederlandse Encyclopedie, 2018). In other words, an underlying motive or reason that is related to making a decision. Simon (1993) describes rationality as highly adapted to goals, finding courses of action that will lead

to goal achievement. Besides, rational decision-making is a conscious process in which managers or other decision-makers take decisions on a conscious level (Woiceshyn, 2011). Thus rational decision-making is a conscious and goal-oriented approach in which decision-makers set goals and are focused on achieving those goals. However, other researchers do not speak literally about a reason or motive, but about collecting information on which the decision is based. For example March (1994), he argues that in rational decision-making, decision makers have clear purposes and are able to collect an appropriate amount of information, mindfully compare different alternatives and evaluate estimated consequences in order to choose an optimal option. And Glass (2008) explains that for taking rational decisions people must collect underlying information and apply specific decision criteria based on the abstraction of decision factors. Dean & Sharfman (1996) indicate more explicitly what the information is about, namely the collection of information which is relevant to the decision and making the decision in reliance upon the analysis of this information. With regard to project selection, it will therefore be gathering information about the various projects from which a selection has to be chosen. The research, analysis and assessment of new product ideas then belongs to the collection of information. Kester et al. (2011) defines rational decision-making from a practical perspective as a process in which decisions are based on knowledge from different functions and perspectives, in which decision makers critically reflect on the understanding of consequences and where market research is done to clearly map out the opportunities. They describe the actions and practices that a firm must carry out if it wants to be rational in making decisions.

Combining these definitions leads to the following definition used in this research; a rational decision has been taken consciously based on underlying motives/reasons, created by collecting relevant information about projects and their opportunities, that enable the achievement of predetermined goals.

#### *2.6.1.2 Intuition*

The opposite of a conscious, reason-based, and goal-oriented decision, which is also called rational, is an unconscious, feeling-based, and no goal-oriented decision. This is also a decision-making characteristic, called intuition. Shapiro & Spence (1997) define intuition as “a nonconscious, holistic processing mode in which judgments are made with no awareness of the rules of knowledge used for inference and which can feel right, despite one’s inability to articulate the reason” (p. 64). Another definition of intuition is set up by Klein (2003) as the act of translating an individual’s experience into action. Okoli & Watt (2018) build further on that and claim that intuition is that every individual is embedded in a continuous flow of experience throughout their lifetime which has an influence on decision-making. These definitions show that intuition evolves from long experience and learning, and is therefore very person-dependent. A top manager who has been in his field for 40 years has gained more experience than a recent graduate. But intuition is not only based on cumulative experience developed over years, but also on feeling. And that also immediately reflects a big difference with rational decisions that are reason-based, while intuitive decisions are feeling-based. In intuitive decisions no concrete goals are set in advance, no information is gathered to substantiate the decision, but it is purely based on past experience and feeling that decision-makers have, in this case, in a particular project. Kester et al. (2011, p. 653) include experiences

and feelings in their definition of intuition: “intuition generates subjective inputs to decision-making through forming opinions about a situation based on past experiences and feelings”. But the critical question arises here is, whether the formation of an opinion is conscious or unconscious? Kester et al. (2011) claim that forming an opinion is done to build a subjective rationale, which is conscious. And because intuitive decision-making is based on unconscious feelings and experience, forming an opinion does not fall under intuition.

All this taken into account, this research makes use of the following definition: an intuitive decision has been taken unconsciously with no specific goal in mind, based on past experiences and feelings about projects and their opportunities.

#### *2.6.1.3 Politics*

The third decision-making characteristic is politics. In the literature of the 1950s, researchers investigated the political perspective on strategic decision-making (Eisenhardt & Zbaracki, 1992). The underlying reason for this is that firms have to deal with people or groups of people with competing interests. This can be because of personal interests, but it can also be different future perspectives, or biased induced by the position in the firm (Eisenhardt & Zbaracki, 1992). Walter et al. (2012, p. 1589) define politics as “intentional attempts to enhance or protect the self-interest of individuals or groups”. Political behavior is basically the outcome of bargaining and negotiation processes among individuals or groups within a firm, due to conflicting interests and goals. This will lead to the following definition of politics in decision-making which is used in this research: the process of persuasion, negotiation and influence to gain informal support driven by the interests or motivations of individuals or groups in a firm (Kester et al., 2011).

#### *2.6.1.4 How the three decision-making characteristics are related with each other*

Even though rationality and intuition in decision-making processes are seen as opposites in this research, with a big difference in the nature of the substantiation – conscious or unconscious – it is possible that a decision is based both on rationality and intuition. According to Khatri & Ng (2000) intuition always plays an unconscious role because it is rooted in a person itself. In addition, Sadler-Smith & Shefy (2004, 2007) argue that rationality and intuition are complementary views, thus decision-makers should be able to use both of them in different decision-making situations concerning project selection. “To be exclusively rational is to mediate all one’s perceptions and actions through a previously articulated frame of reference; to be exclusively intuitive is to relate to the world without the mediation of such a frame”, (Pondy, 1983, cited in Sadler-Smith & Shefy, 2007, p. 190). Burke & Miller (1999) found empirical evidence to claim that managers combine rationality and intuition in decision-making processes, because managers used intuition for guidance if a situation had no predetermined goals, no guidelines or no rules to follow. Kester et al. (2011) claim that rationality and intuition are separate from each other, but that they can interact so that some decisions are based on one or the other, or a combination of both. That is also the perspective that is used in this research. So it is not necessarily the case that both rationality and intuition are used in every decision, what Khatri & Ng (2000) and Sadler-Smith & Shefy (2004, 2007) claim, because it is possible that firms do not use rational processes for selecting projects at all. For example when firms do not have a predetermined goal, when they have no reasons and motives for a specific decision

and when they are not conscious, it is just a decision based on intuition. It is possible that decision-makers have drawn up a specific goal and have that goal in mind, which is rational, but that they select the final projects purely on feelings and experiences.

Dean & Sharfman (1996) claim that politics and rationality can also be combined, which corresponds to Kester et al. (2011), so that decision processes can be rational but not political, political but not rational, both, or neither. Besides, political behavior in decision-making processes can, in relation to rationality and intuition, be conscious or unconscious. It is possible that decision-makers pretend that a certain project is much better than it actually is, because of their own interests. These decision-makers can do this consciously, for example by manipulating the outcomes of certain forecasting calculations, but they can also do that unconsciously, by voting for a specific project which is more aligned with personal interests and/or goals. Thus, political behavior can occur consciously, based on rationality, or unconsciously, based on intuition.

In this research the theory of Kester et al. (2011) and Dean & Sharfman (1996) is used, so that rationality, intuition and politics interact with each other and that every combination is possible. However, politics is seen as a part of one of two; rationality or intuition, as described above. Taking all these relationships into account, figure 6 shows how the three characteristics are relate to each other in this study.

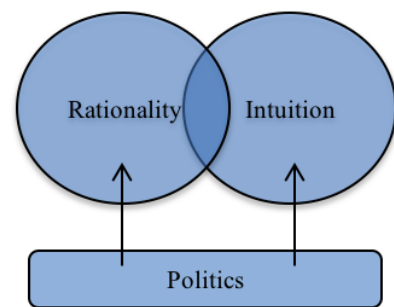


Figure 6: Decision-making characteristics related

### **2.6.2 Level of decision-making authority**

There exist two levels of decision-making authority; top-down and bottom-up. This dimension does not look at the people who influences the decision-making process, but it looks at who make the ultimate decisions regarding project selection (Hutchison-Krupat & Kavadias, 2015). It gives an answer on the following question: who has eventually the authority to make the project selection decisions? In other words, who make the ultimate decisions which new product ideas are actually selected that are being developed further to finally launch in the market? In top-down approaches, the top management determined a fixed resource level to product managers to supervise. On the other hand, in bottom-up approaches, the middle management has the decision-making authority in deciding allocating the resources to projects (Hutchison-Krupat & Kavadias, 2015; Aghion & Tirole, 1997). The top management are the executives, the managing board of a firm, who collectively formulate and implement the strategic and tactical moves of a firm (Eisenhardt et al., 1997), while the middle managers operate below the top management at the intermediate level of the firm hierarchy (Dutton & Ashford, 1993). In this research, the middle managers are often product managers, R&D managers, research managers and/or project leaders. Middle managers provide an integrated product planning which is related to the opportunities of products and the market needs, and that is why they are often seen as the information center for the products in a firm's portfolio (Luck, 1969). Looking at the existing project selection methods in the literature, each method can be controlled top-down or bottom-up, which depends on who has the decision-making authority – top managers or middle managers.

### ***2.6.3 New product idea assessment***

Before the decision is made which projects are selected, new product ideas can be assessed independently or interdependently. Hereby the question arises: how are these ideas assessed? So this is a scoring characteristic. Most of the existing methods select R&D projects by assessing individual projects and then seeking ways to combine the projects for in the portfolio (Chien, 2002). The independent method focuses on the most accurate possible determination of criteria of one project. In other words, the new product ideas are assessed individually. This approach does not look at the influences of adding or cancelling a project on other projects in the portfolio. However, when a manager decides that a certain project is being developed further, this can lead to changes in the decisions for other projects (Diehl & Sterman, 1995). The interdependent approach takes that into account and focuses more on the distribution, e.g. resources and synergies, across all projects. Interdependent methods show managers insights in the impact of adding one new project to other projects in the portfolio (Tohumcu & Karasakal, 2010). In the case of independent methods, the projects are seen separately from each other, whereas interdependent methods see the projects as mutually dependent on each other. Looking at the described methods in the previous section, the only interdependent approach is the bubble diagram. Because bubble diagrams show the impact of adding one project to the portfolio on other projects. All interrelated projects are included in this method.

### ***2.6.4 Weighting of criteria***

The second scoring characteristic is about the weighting of criteria, which means the assignment of values to specific criteria in order to prioritize them based on the level of importance. Decision criteria are often not all equally important in the opinion of firms and therefore firms weigh the criteria in order to give them a certain importance in the decision-making process of project selection (Choo et al., 1999). The questions then arises are: how do firms make a trade-off between criteria? Which criteria do they consider most important? Or do they think everything is equally important and do the criteria have the same weight in making decisions about project selection?

### ***2.6.5 Strategy focus***

The first content characteristic that is discussed here is the strategy focus. Which means that projects are assessed by measuring the strategic alignment of projects (Cooper et al., 2001). Is a new project proposal linked to the firm's business strategy? A firm's business strategy indicates the way a firm determines how to compete in the market in comparison to its competitors (Varadarajan and Clark, 1994). If there is a strategy focus, then the project selection method implies strategic focus as a criteria. The firm's strategy method by Cooper et al. (2001) is a good example for this. The strategic bucket approach focuses on a strategic fit with the firm. Financial methods do not include strategy focus as a selection criteria, and in the other methods it is possible to use it as a criterion.

### ***2.6.6 Market attractiveness***

Market attractiveness is also a content characteristic that looks at how many profit opportunities a market offers and how much potential there is in a particular market for a new product or service (Chandler & Hanks, 1994). Examples of researching market attractiveness, according

to Cooper et al. (2001), are growth potential, consumer needs and general attractiveness. But also pricing trends and information about competitors are important factors to take into account (Porter, 2008). The point here is to get a clear picture of the market for which a new project is being developed to gain knowledge about the extent to which it can be profitable. Market attractiveness can be examined in financial calculations, bubble diagrams, scoring models and checklists, but it is not a criteria in firm's strategy tools (Cooper et al., 2001).

### 2.6.7 Risk

The third content characteristic on which projects can be assessed is risk. "Risk refers to the possibility that the actual return of an investment deviates from its expected value," (Laurikka & Springer, 2003). In other words, risk is the probability of failure of a new developed product or service. Cooper et al. (2001) distinguished risk in technical and commercial. The probability of technical failure is linked to exposure to loss product technologies, for example in manufacturing, technological processes, design and engineering. Commercial risk means the probability of generating less income. In this research, the risk associated with a project is related to the two previous characteristics. Because, for example, when a project has no strategic fit and the market is not attractive, the expected risk is higher.

### 2.6.8 Reward

The last content characteristic is reward, a financial given in recognition of a product or service. Cooper et al. (2001) appoint various financial rewards, such as Return on Investment (ROI), Net Present Value (NPV), payback period and Expected Commercial Value (ECV). These are all calculations to predict the reward that a new project can bring.

### 2.6.9 Characteristics in relation to project selection tools/techniques

The table below show, based on the literature and knowledge gained in previous sections, to what extent the project selection tools/techniques, described in paragraph 2.5, have these characteristics. The two decision-making characteristics are based on the process of decision-making itself, so they are not directly related to the literally based tools/techniques. And the scoring characteristic about weighting criteria depends on which criteria are used in the tools/techniques, so it does not depend on the tools/techniques itself. And that is the reason that this characteristic is not included in table 1.

	Independent / interdependent	Strategy focus	Market attractiveness	Risk	Reward
Financial methods	Independent	No	Yes	Possible	Possible
Strategy methods	Independent	Yes	No	No	No
Bubble diagrams	Interdependent	Possible	Possible	Possible	Possible
Scoring models	Independent	Possible	Possible	Possible	Possible
Checklists	Independent	Possible	Possible	Possible	Possible

Table 1: Characteristics of existing project selection tools/techniques

The question that will be investigated is then which type, which is based on different characteristics, of a project selection method is effective within the high-tech industry and how are the underlying relationships between characteristics and the four goals of effectiveness when the innovativeness of new product ideas is taken into account?

### 3. METHODOLOGY

The methodological approach is elaborated in this chapter. First, an elaboration on why a case study is appropriate is given. After that, the research setting is being discussed, followed by the case selection, data collection, operationalization and the data analysis.

#### 3.1 Research method

To examine which project selection method is effective when taking the innovativeness of new product ideas into account, a case study approach was the most suitable method to go in depth. This research began by finding out some directions for the effectiveness of PPM practices, whereby the context and the complex nature could not precisely be determined in advance, which a case study allows (Yin, 2003). The firm Bo-flow required some organizational changes which were relevant in terms of context, the NPD process and the type of industry. The decision-making process of project selection is hard to delimit and can be very different across firms, for example the people who are involved in this process and the people who make final decisions. Because this study covers a phenomenon that seems to be inseparable from its context and the boundaries between the phenomenon and context are not fully clear, a case study is the perfect method that allows exactly that (Yin, 1981; 2003).

Two other common research methods are the experiment and the survey. A survey and experiment do not allow to go in depth and find underlying reasons about specific topics, which is surely possible during the interviews within a case study. The boundaries and context can then be better examined and understood. The survey and experiment focus on numerical data, while a case study focuses on textual data (Sarkar, 2005), which is far more important in this study due to the fact that this research concerns the decision-making process of project selection and the criteria on which these decisions are based. To understand this process in different high-tech firms, the researcher has to gain knowledge about the way people attribute meaning to this process. And that meaning cannot be investigated only by numerical data. In addition, an advantage of the case study is that researchers can examine a particular phenomenon in detail from different angles (Vennix, 2011). Thus, not only the perceptions of employees are taken into account, but also various documents and observations are used to investigate the phenomenon.

The experiment and the survey are both quantitative methods that are concerned with testing of predetermined hypotheses, while the purpose of a case study is to discover the meaning that people assign to reality in order to be able to understand their actions in real-life (Wester, 1991). This is the case in this research, to look as much as possible 'blank' at the research field and to build a theory about project selection effectiveness. A case study allows researchers to investigate project selection practices in real-life business situations and this approach corresponds to examining under investigated phenomena (Bluhm et al., 2011). A case study is therefore the most suitable method when research and theory are still in the early phases of development in order to build a theory (Eisenhardt, 1989). In addition, case studies are the most appropriate for investigating 'how' something happened (Langley, 1999), and the aim of this study is to acquire knowledge about 'how' a project portfolio selection method can be effective when the innovativeness of new product ideas is taken into account. More specifically, a multiple case study is conducted. This enables exploration of differences within and between

cases (Baxter & Jack, 2008), to ensure that a broader picture can be created of the Dutch high-tech industry.

### 3.2 Research setting

The research setting for this study is Bo-flow, a Dutch high-tech firm. However, for generalizable results, six other firms in the Dutch high-tech industry are included in this study. But what exactly is meant by the high-tech industry? High-tech is an unambiguously defined term. Simply it means technology at the highest level of development. The Dutch government made, in 2011, a distinction in nine top sectors, these are areas in which the Dutch business community and research centers worldwide excel (Rijksoverheid, 2011). The nine top sectors are the following: Horticulture and Propagation Materials, Agri & Food, Water, Life Sciences & Health, Chemistry, High-Tech, Energy, Logistics and Creative Industry.

The high-tech industry stands for “a knowledge-intensive and high-quality range of activities and products ranging from the design and sustainable production of components, controls, devices and machines for business end-users to complex production systems for mass production”, (HTSM, 2011). The following features are specifically related to high-tech firms:

#### Features of high-tech firms

- ❖ technological innovation is of paramount importance in high-tech firms
- ❖ high-tech firms mainly focus on business-to-business markets
- ❖ products in high-tech firms are associated with very high investments in R&D
- ❖ high-tech firms are production firms

Table 2: (HTSM, 2011)

The high-tech firms included in this study have been selected on the basis of these features. In the policy of top sectors, a number of industries fall under the top sector of High-Tech. These are the machine and system industry, automotive industry, aerospace and materials industry, and the steel industry. These industries are engaged in the manufacture of machines, equipment and transport equipment. In addition to these core activities, a number of related activities are included in the sector. These are the development of software for the production, the inspection of the products and production processes, and the R&D part.

### 3.3 Case selection

The case that is being investigated in this study is the decision-making process of project selection, whereby Bo-flow is included as the largest object, but also a comparison is made with other Dutch high-tech firms in order to achieve better generalizable results. Initially it was the intention to interview several people per external firm to get a broader and deeper picture of that firm. But due to practical reasons and the long question list it was not feasible. However, this research is still a multiple case study, with some mini cases. It is relevant to look at the investigated relationships from different points of views, such as different firms and informants. In other words, this research benchmarked current project selection practices in the high-tech industry and investigated multiple relationships.

The selected firms meet the high-tech features drawn up by HTSM (2011), described in the previous paragraph. In addition, the firms have been selected based on the criteria that they are

counterparts to Bo-flow. The selected high-tech firms correspond to Bo-flow to eventually create a clear picture of how the selection of projects works at comparable high-tech firms. So the case selection is not randomly chosen, but reflected Bo-flow to extend the theory to a broad range of firms, in this study the high-tech industry. Eisenhardt (1989, p. 537) defines this as theoretical sampling; “select firms which are likely to replicate or extend the emergent theory”. The following criteria have also been used to select high-tech firms that are considered as a counterpart to Bo-flow: (1) located in the Netherlands, (2) operating internationally, (3) no competitor of Bo-flow and (4) market-oriented. When a firm is market-oriented, it does not only focus on the needs of their customers, but also on the plans and capabilities of their competitors (Slater & Narver, 1998). Market-oriented firms identify the market more broadly with a greater focus on the long-term. Slater & Narver (1998) also argue that market-oriented firms are generative learners, which according to Senge (1990) is critical to innovation. See table 3 on the next page for an overview of the case selection. All names are fictional.

### **3.4 Data collection**

Methods of data collection indicate how empirical sources are exposed (Verschuren & Doorewaard, 2007). In this research, data sources included the knowledge and information from in-depth semi-structured interviews, observations and studying firm’s documents, to enable triangulation which a case study allows (Yin, 2003).

#### **3.4.1 Interviews**

13 semi-structured interviews are used as the primary method for data collection, because a certain degree of openness in the data is preferable to create in-depth understanding about the relationships investigated in this research. The interviews are conducted with different managers of several high-tech firms who are involved in the project portfolio selection process. The interviews were conducted face-to-face and have allowed informants to elaborate on answers, which results in more depth of the explanations. Because PPM effectiveness is a multidimensional concept representing different aspects (Patanakul, 2015), managers with different job functions were interviewed in this study to create a picture as clear as possible. Informants included project leaders, R&D managers, marketing and sales managers, but also a managing director. These managers originate both internally (within Bo-flow) and externally (other high-tech firms). It has been decided to interview one person at each external firm, who is involved in the decision-making process or project selection, in order to create the broadest possible picture of the high-tech industry. There has been good contact with the external firms in question to be eligible to interview the right person. The table in Appendix 3 shows an overview of the informants.

To gain all the necessary knowledge during the interviews, the researcher pursued a consistent line of inquiry by using a question list, but the questions are more likely to be fluid rather than rigid (Yin, 2003). Before a definitive start was made on the interviews, the researcher first took two pilot interviews. During the first pilot interview, the question list was still far from the point of departure, but the intention was to get a feeling with interviewing, asking questions and not being biased. The second pilot interview was conducted to see to what extent the question list was precisely enough, so that all relations were discussed.

Table 3: Case selection

	<b>Cases</b>						
	Bo-flow	Ntech	Prowater	Noisearch	Veprcise	PPA	Spe-metal
<b>Information</b>							
Product	Low flow meters	Contactless communication technology	Water pumps	Soft- and hardware for behavioral research	Different high precision products	Complex micro assemblages	Electronic and hydraulic press brakes
Industry	High-tech	High-tech	High-tech	High-tech	High-tech	High-tech	High-tech
Founding year	1981	1929	1904	1989	1934	2013	1960
Number of employees	525*	680*	160*	160*	220*	16	160*
Stock market listed firm	No	Yes	Yes	No	No	No	No
<b>Criteria</b>							
Technolog. innovation	✓	✓	✓	✓	✓	✓	✓
B2B markets	✓	✓	✓	✓	✓	✓	✓
High investments R&D	✓	✓	✓	✓	✓	✓	✓
Production firms	✓	✓	✓	✓	✓	✓	✓
Located in NL	✓	✓	✓	✓	✓	✓	✓
Operating international	✓	✓	✓	✓	✓	✓	✓
No competitor of Bo-flow	-	✓	✓	✓	✓	✓	✓
Market-oriented	✓	✓	✓	✓	✓	✓	✓

\*approximately

After transcribing that pilot interview, the researcher discovered that there were still some uncertainties and that the relationships were not explored properly. Subsequently, the questionnaire was adapted in such a way that the relationships could be explored more detailed during the rest of the interviews.

This research aims to improve the understanding of project selection methods to help guide managers in the high-tech industry how to create the most effective project selection method, and to what extent the difference between radical, really new and incremental innovation projects influences that process. To explore all these relationships in a structured way, the question list for the interviews was divided in part I, II and III. Part I is a descriptive part in which project selection practices of the respective firm were mapped, in order to acquire knowledge about the current method that the firm uses to select projects. Part II gives insights in factors that have an influence on the dependent variables, namely the four goals of effectiveness. The characteristics identified in the literature review are not explicitly mentioned here, in order to prevent a bias from occurring. The researcher has just adopted an attitude to be open for new characteristics and their effects on the four goals of effectiveness. In part III it is reversed. This part looked at the impact that the independent variables, characteristics, have on project selection. The researcher assumed an open attitude and did not appoint the four goals of effectiveness, but identified them and ask further questions about the relationships. In addition, in part III the moderating effect of the innovativeness of new product ideas has been investigated among the different relationships.

### ***3.4.2 Participant observation***

In order to create a better understanding of the decision-making process of project selection at Bo-flow, participant observation is also used in this research. Because project selection is a decision-making process in which members of a firm interact with each other and discuss different projects, participant observation is a right way to observe and experience these situations. That is why the researcher spent six months in the department of the product managers at Bo-flow and therefore was able to observe certain situations and consultations between members within the firm. The researcher has kept memos of relevant circumstances that took place on the work floor of Bo-flow which can be related to the research phenomenon.

### ***3.4.3 Documents***

Another method of data collection is document reviews. Much information can be acquired on the basis of documents from now and from the past. Acquiring information regarding project selection and the learning process, the objectives of Bo-flow and other firms, as well as the vision and mission, etc. From this information, the researcher has made an analysis for returning topics during the interviews. In addition, the researcher has also gained access to several internal documents dealing with project selection. It concerns powerpoint slides of information meetings, growth phase models, business canvasses, etc. All these documents provided insights into the formal processes in place for the decision-making process of project selection, without the opinion of individuals.

### 3.5 Operationalization

The following operationalization table, gives an overview of the different dimensions that are discussed during the interviews. Table 4 splits the three constructs of the conceptual model in dimensions and indicators. The questions in the question list cover all these indicators. The question list is shown in Appendix 4. The operationalization of all dimensions are explained in the next sections.

Construct	Dimensions	Indicators	Source
Types of project selection	Rationality	- Consciously - Based on underlying motives/ reasons by collecting relevant information - Achievement of predetermined goals	e.g. Kester et al. (2011), Dean & Sharfman (1996)
	Intuition	- Unconsciously - Based on past experiences and feelings - No predetermined goals	
	Politics	- Consciously or unconsciously influence, persuasion and/or negotiation driven by personal goals and interests	
	Top-down	- Decision-making authority by managing board	Hutchison-Krupat & Kavadias (2015)
	Bottom-up	- Decision-making authority by product managers	
	Independent assessment	- Separate project evaluation	Tohumcu & Karasakal (2010)
	Interdependent assessment	- Mutually dependent project evaluation	
	Weighting of criteria	- When one or more criteria weigh higher than others	Set up for this research
	All equally important	- When all used criteria weigh equally the same	
Strategy focus	- Clarity about strategy - Using as a criteria	Patanakul (2015)	
Market attractiveness	- Doing market and consumer research about attractiveness and use it as criteria	Set up for this research	
Risk	- Using as a criteria	Set up for this research	
Reward	- Using as a criteria	Set up for this research	
Project selection method's effectiveness	Strategic alignment	- Projects in portfolio must underset the business strategy - Resource allocation aligned with business strategy	Cooper et al. (2001) Dietrich & Lehtonen (2005)
	Maximize value	- An high expected financial value of selected projects	Cooper et al. (2001) Patanakul (2015)
	Balanced portfolio	- Firm's overall risk spread over a mixed combination of projects	Cooper et al. (2001) Mikkola (2001)
	Right number of projects	- A well consideration between available resources and projects	Cooper et al. (2001)
Innovativeness of new product ideas	Radical product innovation	- Macro-marketing discontinuity and - Macro-technology discontinuity	Garcia & Calantone (2002)
	Really new product innovation	- Macro-marketing discontinuity or - Macro-technology discontinuity	Garcia & Calantone (2002)
	Incremental product innovation	- No macro discontinuity, only micro discontinuity	Garcia & Calantone (2002)

Table 4: Operationalization table

### ***3.5.1 Types of project selection***

The formulated characteristics have been identified during the literature study and the theoretical framework. They are based on the existing project selection methods that are described in paragraph 2.5. The dimensions are operationalized in the following way.

The first dimension is about rational, intuitive and political decision-making. In the previous chapter these three characteristics have been defined on the basis of the literature. A number of similarities and differences between these three characteristics have been clarified. But how are they measured in practice? First, rationality. Decision-makers take rational decisions when they first critically think about the alternatives and make a decision thereafter, which means conscious thinking (Woiceshyn, 2011). To think critically about all the alternatives, which are the proposed innovation projects, decision-makers have to collect relevant information and have set a goal in advance that they want to achieve. These are the three aspects that belong to rational decision-making. Intuitive decision-making happens at an unconscious level (Shapiro & Spence, 1997). Unconscious is behavior that decision-makers carry out without thinking about the decision and the alternatives. They also do not have a predetermined goal in mind. But the decision-makers take their past experience and feelings into account to determine which decision they make (Kester et al., 2011). Thus, when decision-makers do not collect relevant information, do not think about all the alternatives, do not have a predetermined goal in mind, but just make a decision based on experience and feelings, it is intuitive. The third aspect is political behavior. When decision-makers, individuals or groups, make a choice based on their own interests, to pursue their own goals, such as a promotion, then it is called politics (Kester et al., 2011). And this behavior can occur both consciously or unconsciously, so it is part of rational decision-making or intuitive decision-making. When the assessment of new product ideas is manipulated, decision-makers consciously demonstrate political behavior. But when they do not manipulate something, but unwittingly express their preference about a particular project they are more interested in, then it belongs to intuitive decision-making.

The second dimension, the top-down and/or bottom-up approach, has been operationalized as follows. When the managing board has the ultimate decision-making authority with regard to project selection, it is seen as a top-down approach, but when the product managers have the authority to select projects, it is a bottom-up approach (Hutchison-Krupat & Kavadias, 2015). When the opinions of both middle managers and top managers count equally heavily, it is also considered as a bottom-up approach.

The following dimension is about independent and/or interdependent assessment and this is measured as follows. When projects are assessed separately from each other, this is considered as independent. When projects are mutually dependent on each other and the impact on other projects is taken into account, this is an interdependent approach (Tohumcu & Karasakal, 2010). The interdependent approach accounts for interdependencies between project evaluation, such as synergies.

The next dimension deals with the weighting of criteria and is also operationalized in two opposites. When there is weighting of criteria, some criteria outweigh others and are more important. The opposite is when all criteria used are equally important and therefore of same importance during the decision-making process of project selection.

The last four dimensions of the construct ‘types of project selection’ are content characteristics. These are criteria and measures that are used to evaluate projects and compare them with each other in order to select the right projects for a firm’s portfolio.

The first dimension is strategy focus. This dimension has been measured in terms of two measurable variables set up for this research; clarity about the strategy and the extent to which decision-makers have the strategy in mind when making portfolio decisions. To create an effective portfolio, the decision-makers of project selection must understand the firm’s business strategy and select projects based on that strategic direction (Patanakul, 2015). Because, when the business strategy is not clear and not in mind, choices are not based on that and that means no strategy focus. When both variables are met, strategy focus is accomplished. The second scoring characteristic is market attractiveness and this dimension is operationalized in using market and consumer characteristics for predicting the profitability and potential of a new project. Doing market and consumer research about attractiveness is extremely important here and inevitable.

The last two scoring characteristics are risk and reward. Both are measured in the same way. When a firm uses risk or reward as an important criteria for selecting projects, then that specific characteristic can be considered as important in the project selection process.

### ***3.5.2 Effectiveness***

But how are these characteristics related with the four goals of PPM, based on Cooper et al. (2001), to achieve effectiveness? The four goals are operationalized in the following way.

When a firm’s portfolio fits with its business strategy, it accomplishes strategic alignment, the first goal (Cooper et al., 2001). Patanakul (2015) found evidence that the degree to which a portfolio fits with the firm’s business strategy can be used to measure project portfolio effectiveness. But this strategic fit is too vague to measure this goal. However, Dietrich & Lehtonen (2005) elaborated an empirical research on successful management of strategic intention through multiple projects. They have found evidence that the following conditions must have been met when the portfolio is strategic aligned: projects in the portfolio must underset the business strategy and the resource allocation is aligned with the business strategy (Dietrich & Lehtonen, 2005). Thus, an effective project portfolio must reflect the firm’s strategic direction.

The second goal is maximizing value, which is accomplished when a firm selects new projects in a way to maximize the commercial value of the portfolio (Cooper et al., 2001). Unfortunately, the selection of projects can never be looked back on. For firms it is not possible to find out what the commercial value of a portfolio would have been if they had previously selected other projects. That is why this goal is measured by looking at the choices that have been made in recent times. Thus, when projects are selected in the portfolio on the basis of an high expected financial value in comparison to other projects with lower expected value, this goal of effectiveness is met.

The third goal of effectiveness is creating a balanced portfolio in order to spread the firm’s overall risk over a mixed combination of projects (Cooper et al., 2001; Mikkola, 2001). To measure this, a firm’s portfolio must contain a combination of different types of projects based on several parameters, so that the overall risk is spread and the firm can better withstand some obstacles or shifts in customer needs. Some parameter examples are: project size, time frame,

different markets, innovativeness, project type, etc. The parameters are different for each firm based on their strategy and business environment (Chao & Kavadia, 2008).

The fourth goal is about picking the right number of projects based on the available resources (Cooper et al., 2001). When a portfolio has more projects than a firm's resources can support, the project selection has failed on this goal. But also when a firm does not have the right resources, such as knowledge, this goal of effectiveness is not met.

### 3.5.3 Innovativeness of new product ideas

The third moderating construct which is taken into account is the innovativeness of new product ideas described in section 2.1.1. Garcia & Calantone (2002) have 'innovativeness' operationalized in radical product innovation, really new product innovation and incremental product innovation. This operationalization is also used in this research and is shown in the following figure.

Inputs*: Discontinuities				Outputs: Innovation Type		
Macro-Marketing Discontinuity	Macro-Technology Discontinuity	Micro-Marketing Discontinuity	Micro-Technology Discontinuity	Radical Innovation	Really New Innovation	Incremental Innovation
1	1	1	1	1	0	0
1	0	1	0	0	1	0
0	1	0	1	0	1	0
1	0	1	1	0	1	0
0	1	1	1	0	1	0
0	0	1	1	0	0	1
0	0	1	0	0	0	1
0	0	0	1	0	0	1

\*note: other combinations are not feasible, if an innovation results in a discontinuity on a macro-level, the discontinuity will also occur on a micro-level.

Figure 7: Operationalization innovativeness (Garcia & Calantone, 2002)

Figure 7 makes it clear that a radical product innovation includes both a marketing discontinuity and a technology discontinuity on the macrolevel, while really new product innovation includes one of these two, and incremental product innovation does not include a macro discontinuity, but only discontinuity on the microlevel (Garcia & Calantone, 2002). To better understand these indicators, they are explained here further with a few examples. First of all, what exactly is meant by macrolevel and microlevel? Garcia & Calantone (2002) describe a macro perspective as looking at the impact of a product innovation on the world, a market or an industry, while the microlevel focuses on the firm or the customer. This distinction provides more insights into the perspective from which the newness of a product innovation is looked. When the innovativeness of new product ideas is evaluated through exogenous factors to the firm, is it from a macro perspective, for example familiarity of an innovation to the world or the creation of a totally new market. But also the new entrants of competitors who also want to develop and implement this innovation is seen as a macrolevel discontinuity. From a micro perspective, innovativeness is evaluated based on discontinuities within the firm, such as a new marketing strategy, new suppliers or a new distribution, which can have an impact on the customer.

In addition, Garcia & Calantone (2002) have also made a distinction in marketing discontinuity and technology discontinuity. A marketing discontinuity is basically a shift in the market structure in an industry (macro) or new marketing skills (micro), and a technology discontinuity is a shift in the science and technology that a product includes, such as new R&D resources or new components. When the technology is new for the market or industry, is it on the macrolevel, and when it is only new for the firm or customer, it is from a micro perspective.

From this point, really new product innovations are mostly new product lines, new markets with existing technology or product line extensions in the same market with new technology.

The question that this research poses here is how does the innovativeness of new product ideas influence the relationship between types of project selection methods and effectiveness? So, are there other types of project selection methods effective for a radical product innovation compared to an incremental product innovation?

### **3.6 Data analysis**

This research is based on inductive reasoning in order to form a theory about the relationship between characteristics of project selection methods – including moderator innovativeness – and effectiveness. Each interview has been recorded and transcribed. All the transcripts were coded to develop the chains of evidence. Coding of transcripts works well to capture the commonalities of experiences across cases but less well to capture the uniqueness of individuals within these cases (Ayres et al., 2003). The coding is done as follows. First, the transcribed interviews are fully read and open coded. This means that certain labels (codes) have been added to certain text fragments. Second, the next step is axial coding, where the codes are compared with each other and those that belong to each other are added together within an overarching code. Third, the final phase of the coding process is selective coding. This is done by placing all codes within the main categories and based on this, establishing relationships and connections between the collected data.

So, for each firm, within-case analysis was conducted in order to identify unique answers that are only of interest to that specific individual, based on his or her background and principles. Cross-case analysis was also conducted to find similarities and differences between high-tech firms. The pattern-matching technique is used in order to analyse the data. This analytical technique compares an empirically based pattern with a predicted one (Yin, 2003). The predicted pattern is based on the existing literature about project portfolio selection methods described in paragraph 2.5. After conducting these analyses, the findings were compared with the current state of project selection methods and practices described in the literature. This together will create an answer on the research question.

### **3.7 Research ethics**

In qualitative research it is important to handle data sensitively (Symon & Cassell, 2012), especially in this research where several informants from different firms have been interviewed. Regarding the openness and confidentiality in data collection, the informants have been informed on the wider nature and the objectives of this research, before authorization is given by the informant. Furthermore, the informants are asked for their permission to record the interview and what the researcher can and cannot tell in the report in order to respect the privacy. In addition, fictional names were used to ensure the confidentiality and anonymity.

## 4. RESULTS

The results of this research will be discussed in this chapter. In paragraph 4.1 and 4.2, the current project selection practices in different high-tech firms in terms of effectiveness are brought to the attention. Hereafter, the relationships between characteristics of project selection methods and the four goals of effectiveness are discussed in detail in paragraph 4.3. And the last paragraph 4.4, deals with the findings regarding the moderating effect of innovativeness.

### 4.1 Current project selection practices

7 high-tech firms located in the Netherlands have been included in this study. This paragraph answers the first part of sub-question 2: *What are the current practices in different high-tech firms concerning their project selection in terms of effectiveness?*

In this research, a project selection method means the decision-making process around project selection in combination with a tool/technique that supports firms with assessing new product ideas in order to make decisions. To better understand and distinguish project selection methods, three types of characteristics have been identified: decision-making characteristics, scoring characteristics and content characteristics, which are also explicitly discussed in this chapter.

The interviews have shown several differences and similarities between the high-tech firms. First of all, two important characteristics have not been described in the literature review, but which do play a major role in project selection methods. These are the following two content characteristics: effort and capacity. These two criteria are considered important by most informants or are partially included in tools/techniques to support decisions about project selection. Especially the capacity, a project can actually not be selected when the available capacity does not allow it.

*“.. an assessment of the opportunities, what are the risks if we do not do it, but also what capacity we have available and what we can handle as a firm. Make your choice based on that.”* – Manager Marketing & Sales Bo-flow (I2)

Two other informants added:

*“.. the capacity issue is very important.”* – Product Manager Analyst Bo-flow (I5)

*“.. the way we react to it is simple: more demand means making more capacity available.”* – R&D Manager Veprecise (I11)

To create an overview of the current project selection practices in high-tech firms, table 5 on the next page shows the differences and similarities in which the characteristics come to light. In the first row it is clear to note that all firms use a decision-making process that is controlled both rationally and intuitively. Firms prefer to involve as much rationality as possible, but that it is impossible to exclude intuition. The relationship between these two characteristics is explained in more detail in paragraph 4.3. The second row indicates the current presence of political behavior relatively in high-tech firms. Unfortunately, no proof was found about the presence of political behavior at Prowater and Nolsearch. It has been shown that when political behavior occurs within high-tech firms, that it happens unconsciously and not through manipulation. The third row shows whether the decision-makers are top managers or middle managers.

Table 5: Current project selection practices

<b>Cases</b>							
	Bo-flow	Ntech	Prowater	Noisearch	Veprecise	PPA	Spe-metal
<b>Decision-making characteristics</b>							
Rationality/intuition	Combination	Combination	Combination	Combination	Combination	Combination	Combination
Political behavior	Medium	Low	-*	-*	Low	Low	Low
Level of authority	Top-down	Bottom-up	Top-down	Bottom-up	Depends on the amount of investment	Bottom-up	Top-down
<b>Scoring characteristics</b>							
New product idea assessment	First independent, then interdependent	Independent	First independent, then interdependent	Interdependent	First independent, then interdependent	First independent, then interdependent	Interdependent
Weighting of criteria	Weighting	Weighting	Weighting	Weighting	Weighting	Weighting	Weighting
<b>Most important content characteristics</b>							
Strategy focus	-*	✓	✓	-*		✓	
Market attractiveness	-*			-*			
Risk	-*		✓	-*			
Reward	-*	✓	✓	-*	✓	✓	✓
Capacity	-*			-*	✓		✓
Effort	-*	✓	✓	-*			

\*no data

In some firms it is top-down driven, in some bottom-up, and at Veprecise the level of the decision-making authority depends on the amount of the investment. From this it can be concluded that it happens in different ways and that depends on how the firm want to tackle it. What applies for the level of decision-making authority, also applies for independent and interdependent assessment of new product ideas, according to the fourth row. From the fifth row it can clearly be concluded that all firms use a weighting of criteria. In other words, every firm finds certain criteria more important and weigh those more heavily in the decision process. Which criteria firms find the most important can be derived from the rows beneath most important content characteristics, where various differences can be seen. This has to do with the business strategy, appears from the quotations below.

*“The fact that some criteria are more important than others at the moment is related to the way you want to act as a firm. And then criteria are adhered to that.”*

– Manager Product Marketing Prowater (I9)

*“Look, if you look at our corporate philosophy, you have taken a number of things into account. That is also incorporated in our mission and vision. There you just see that a number of things come out very strongly which are more important than others.”* – Accountmanager PPA (I12)

In order to compare the current project selection practices in high-tech firms with the tools/techniques that Cooper et al. (2001) describes for the assessment of new ideas, scoring models are mostly used on the basis of established criteria that firms consider important. In addition, some high-tech firms also assess projects by making financial calculations, mainly return on investment. However, bubble diagrams and strategic bucket approaches hardly appear, has emerged from the interviews. When looking at the decision-making process, it can be concluded that the majority of the high-tech firms make decisions by means of consultation. In contrast to Bo-flow and Nolsearch, because they execute it on the basis of pitches that are subsequently assessed by a group decision-makers. Additionally, only Nolsearch follows a stage-gate model as a manual for the decision-making process.

To better understand the differences and similarities between project selection methods with regard to the characteristics, the project selection practices of each firm are briefly described in the coming sections. The characteristics, also shown in table 5, are described **in bold**.

#### **4.1.1 Bo-flow**

Based on an informative presentation at Bo-flow, Bo-flow has grown in the last years with a significant increase in employees. However, to maintain this growth, the new managing director has changed the organizational structure since January 1, 2018. One of the changes is the introduction of a product management group and a group with industry specialists. This new structure is a result of the problem that arose in the previous organization structure, concerning ownership about who is responsible for which tasks and activities. In the past, that ownership existed in many different departments and different people, what was not clear to everyone, causing that there was no specific guideline or procedure for selecting new projects.

*“There was no ownership, there were no roadmaps, there were at most people who called something and people who liked something, and someone who accidentally convinced others to go in his direction. But there was no critical look or someone who asks questions.”* – Managing Director Bo-flow (I3)

It was also called "beep management" by a Product Manager Analyst (I5), in other words; who shouts the loudest gets the most attention. The decision-making process of project selection happened purely on feelings. There was no question of **rationality**, according to the informants. They had no specific goal in mind and no relevant information was collected on which choices were based. In the case that an employee had a good feeling about something, he or she tried to convince others, and so the project was selected and executed.

Since the beginning of 2018, the project selection method has changed for the above reasons. Every product manager is now linked to its own product line and requests for new projects end up on their plates. When an idea is interesting enough, they will work it out in business canvasses. In Appendix 5.1 an example of an empty business canvas is included. Different criteria are taken into account and investigated. Then the product managers will present this project with a pitch during a Dragons' Den meeting where they get the chance to convince the 'Dragons', in this case the managing board, so that the project will be selected. During the Dragons' Den, the different projects were assessed on the basis of a decision criteria list, a scoring model, from which a score per project followed. This list can be found in Appendix 5.2. Based on this decision criteria list and on the pitches of the product managers, new projects are refused or selected. This has led to a more rational form of the decision-making process.

The following quote supports this:

*".. and that is why we have also introduced the business canvasses and the Dragons' Den. To give it a more rational form. Yet I am of the opinion that there is always a bit of gut feeling. But we cannot just continue to do so, because A, the world is changing, everything goes faster and you name it, and B, the gut feeling of the owners, the founders, is simply unique. You cannot find 5 people on the street with that gut feeling."* – Managing Director Bo-flow (I3)

The decision-makers make conscious choices based on underlying information. However, it can be concluded from the interviews that the goals Bo-flow wants to pursue are not clear for everyone because of having no concrete and well-defined strategy.

*"I can say that Bo-flow exists, that Bo-flow has grown all these years, but that Bo-flow does not have a very clear dot on the horizon, except for continuity."*

– Managing Director Bo-flow (I3)

The following quote substantiates this:

*"We do not really have a clear strategy. What do we really want?"* – Product Manager Bo-flow (I6)

From this can be deduced that Bo-flow tries to make the decision-making process of project selection as **rational** as possible, but that **intuition** still plays a role. In addition, it appears that there is some question of **political behavior** in the managing board who has the **decision-making authority**. And the opinions and needs of sales men are often different from those of R&D managers according to Manager Marketing & Sales (I2), which leads to a medium presence of political behavior. In addition, the product managers indicated that when they were allowed to make the choices together with regard to project selection, there would be mutual competition and personal goals or interests would prevail.

The **assessment** of new ideas is first done independently of each other at Bo-flow. When product managers have worked their ideas out, the mutual dependency between projects is considered. For example, the influence of selecting a new project on the resources of other projects, or when synergies can be created between projects.

*“The product managers prepare the canvasses independently, from their own perspective, together with an R&D partner. But it is then my job to assess the mutual dependency between projects and see to what extent we can take that with us, or what can be derived from it.”* – Product Manager Analyst Bo-flow (I5)

From the interviews it emerged that Bo-flow uses different criteria for selecting or not selecting projects, as the decision criteria list in Appendix 7.2 indicates. All informants indicate that some criteria outweigh others, but opinions differ on which criteria are the most important. This has not yet been worked out well in the new project selection method that has been used since the beginning of this year. According to the Manager Marketing & Sales (I2), reward is the most important criteria, because after all, a project has to generate money. A Product Manager (I6) is of the opinion that the risks and market attractiveness are the most important, because then the reward will follow automatically. But can a project be selected if there are no available resources? Because of this question, the Product Manager Analyst (I5) finds effort and capacity very important criteria to take into account. In conclusion, informants at Bo-flow think that some criteria should weigh more than others, but there is still no consensus about which criteria.

#### **4.1.2 Ntech**

Ntech has divided its business into various business units. The two informants of this case belong each to a different business unit; the Business Developer (I7) belongs to business unit X, and the Project Manager (I8) belongs to business unit Y. In the interviews, these two informants indicated that all business units are actually independent firms that belong to Ntech. The business units pursue the overarching corporate strategy of Ntech, but have their own business strategies and project selection method. Therefore, both methods are described separately from each other in the following two sections.

##### **4.1.2.1 Business unit X**

Projects are selected in an organic way within business unit X, through consultations and meetings. They do not use a decision support system or a specific procedure for selecting projects. They do use a lean method, but that mainly affects the development and execution of a project, not the selection beforehand. But as Bo-flow uses the Dragons' Den for example, this business unit does not have a decision support system according to the Business Developer (I7). During meetings, new ideas are discussed and everyone can expose his or her opinion. Eventually, it is decided together which project or projects are selected. Thus, the middle managers have the **decision-making authority** which means that projects are selected top-down. Furthermore, the **assessment** of new ideas happens during meetings independently of each other on the basis of a graph. The following quote explains this graph:

*“One of the most important things, easy said, is actually a trade-off between 'effort' and 'impact'. We then draw a graph with an X and Y-axis, the amount of effort and amount of impact, and you simply plot all the different options on that graph.”* – Business Developer Ntech (I7)

In this process, **effort** means the time and resources you need to achieve your goals, and the impact holds on the **reward** a firm intend to achieve with it, according to the Business Developer (I7). The intention what a firm tries to achieve with a project depends on the goals a firm strives for. And those goals are again derived from the clear strategy that is being

pursued. In other words, it can be concluded from this that business unit X of Ntech has mapped out a clear strategy with associated concrete goals. When a new idea in the graph scores well on one of those goals under 'impact', with as little 'effort' as possible, then the chance is much greater that the project is selected compared to another project. Then, it only depends on whether there is enough capacity available to carry out the project (Business Developer, I7). From the above it can be concluded that the decision-makers in business unit X have clear goals and make conscious choices based on this. These are two aspects that belong, in this research, to **rationality**. Yet it is not inseparable from **intuition**, and that is evident from the following quote:

*“If I look at our rationality, then I think that is very important and worked out in a rational way. You have to base a choice on something. But that always includes gut feeling.”* – Business Developer Ntech (I7)

The third decision-making characteristic, **political behavior**, is fairly tempered within this business unit, according to the following quote:

*“.. because it is looked at from different perspectives and people. So I think that this behavior is pushed away reasonably well.”* – Business Developer Ntech (I7)

#### 4.1.2.2 Business unit Y

The interviews have shown that business unit Y uses a very different project selection method than business unit X. Where the selection of projects within business unit X is very organic, more structure is added to the decision-making process in business unit Y. To start with, ideas come in via the online IdeaPortal in which the ideas are already based on some relevant information (Project Manager, I8). The Project Manager (I8) mentioned that the decision-makers do not specifically search for interdependencies between projects, so the projects are **assessed** independently of each other. These new ideas are discussed and selected during a group meeting of six different oriented middle managers who have the **decision-making authority**. According to the Project Manager (I8) this also limits **political behavior**, because if you can discuss an idea from different disciplines, all perspectives are taken into account and not one person can push through his or her personal goals and interests. The same as with business unit X, the decisions about project selection are made during meetings. But here, the six decision-makers use a criterion list where a score per project is rolled out, a scoring model, and it is also checked whether it fits within the roadmap that they have drawn up and updated every year. The Project Manager (I8) indicates that these criteria are mainly qualitative, for example a **strategy focus** and operational efficiency. So no calculations with regard to the expected reward and risks.

*“So it is mainly related to our strategy; to what extent does it fit our strategy, to what extent is it for retaining existing customers or for recruiting new ones.”* – Project Manager Ntech (I8)

This indicates a difference between the two business units of Ntech, and that is mainly in the criteria. However, the criteria used by business unit X are clearly based on the strategy and the goals that are attached to it, but are more converted into a figure and numbers, while it is by business unit Y more based qualitative information.

Because of the qualitative criteria used when making decisions about project selection, **intuition** plays the main role according to the Project Manager (I8). She said the following about this:

*“Those arguments, even if you think you are making such a rational decision, are still intuitive. We always try to do analyses. We always try to get as much information as possible above the table, so that you have to make as few assumptions as possible based on assumptions. So it is well founded, but still gut feeling.”* – Project Manager Ntech (I8)

Although the informant indicates that the choices are mainly based on gut feeling, the researcher sees this differently. The interview clearly shows that relevant information is sought and that the choices are consciously based on them. This is seen as **rational** in this research. However, the business strategy is not yet clear as a result that the goals are not well formulated either. Thus, at the moment, this part is being done more on a feeling, but they ultimately endeavour to formulate clear goals.

#### **4.1.3 Prowater**

Prowater is part of a large international firm, where the strategic directions are decided by the managing board. The interview with the Product Marketing Manager (I9) showed that Prowater must report to the managing board with regard to proposals for new projects. New ideas are presented to the top managers during regular, as the Product Marketing Manager (I9) called it, product council meetings, which are meetings through skype. The managing board has the ultimate **decision-making authority** about whether or not to select a project, but the information for this was delivered bottom-up.

*“So with relatively standard procedures, a good business case, financially supported, it can be a good plan locally. But then it can still be that they disapprove it worldwide.”* – Product Marketing Manager (I9)

The **assessment** of new ideas at Prowater is first done independently, just like at Bo-flow. This is executed by means of a model in Excel. The following quote explains that clearly:

*“We have a kind of system in an Excel model which we first fill in. And at some point something just rolls out. You have to assign certain values whether it fits the strategy, whether it is risky, how much time we need to implement it, how much can we earn on it. On this basis, certain gradations are adhered to a project.”* – Product Marketing Manager (I9)

The most important criteria that Prowater uses for selecting or not selecting a new project are also mentioned in this quote; **strategy focus, effort, risk** and **reward**. Afterwards, they examined which mutual dependencies can play a role (Product Marketing Manager, I9), for example whether certain knowledge gained can also be useful for another project. The decision-makers take that into account by making choices about project selection.

It can be concluded that Prowater performs the decision-making process in a **rational**, yet **intuitive** manner. First, it can be seen as rational because of the clear goals the decision-makers have in mind when selecting new projects. This is shown by the following quote:

*“We have a number of markets for which we have chosen, we have a number of market segments with applications and we are really focusing on that.”* – Product Marketing Manager (I9)

The second rational aspect here is collecting relevant information to make assumptions and predictions as good as possible on the basis of this. The interview with the Product Marketing Manager (I9) showed that good research is conducted beforehand. From this, it can be concluded that the decision-making process is mainly rational. But, the informant is of the

opinion that you cannot call it rational, because you always include a certain feeling in your decision, according to the following quote:

*“You cannot rely on numbers alone. I do not think you should build on that. You have to take a little gut feeling in your decision.”* - Product Marketing Manager (I9)

The interview with the informant did not reveal the current status of **political behavior** within Prowater. However, the Product Marketing Manager (I9) did indicate that personal goals are always related to business goals, so that political behavior cannot have a bad influence. The informant refers to a sales person who has personal goals to sell a certain product as much as possible.

Furthermore, Prowater and Ntech are listed on the stock market, but it can be concluded that this has no influence on the way of selecting projects. Reporting activities plays a somewhat larger role at Prowater, but nevertheless there are no specific criteria attached to selecting new projects because of the stock exchange listing, which is the same at Ntech.

#### 4.1.4 Nolsearch

Nolsearch has since the beginning of 2018 switched to a new project selection method based on lean and agile with different stages, according to the Product Manager (I10), wherein more short cycles for new product innovations are implemented. The purpose of this transition is to create more guidelines for the employees, so that everyone clearly knows what to do if they have a new idea and what the next steps are they must take (Product Manager, I10).

*“.. to make the transition to actually an official Noldus product, that did not get off the ground. So we have changed that now, by following several steps, gates.”* – Product Manager Nolsearch (I10)

To begin, the Nolsearch Business Development department and the R&D department were merged into the so-called Innovation Board. This board has the **decision-making authority** for selecting new projects, which are both middle managers and top managers. Currently they are working on the implementation and use of a Kanban method:

*“You have an ideas list, a maximum of ten. And if more ideas are added, we streak the least attractive away. And two of these actually go in a project. So there are always about two in a project. So at the moment that one project is completed, either because it is successfully developed as a product or that we still say at a certain moment; this is not the case, then another idea can be developed as a project.”* – Product Manager Nolsearch (I10)

To better understand this Kanban method, the Product Manager (I10) drew the following schedule on the whiteboard during the interview.

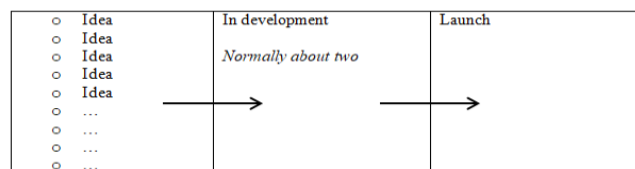


Figure 8: Nolsearch' Kanban method

In this way they ensure that there is a continuous flow of new projects and that investments are always made in new product innovations. But before an idea reaches the list with ten ideas, it must first be selected by the Innovation Board. And for this, Nolsearch uses an initial stage in which the person with an idea has to explain it in a 'one page' which will then, together with a

pitch, be brought under the spotlight by the Innovation Board. Eventually, the members of the Innovation Board take the decision regarding whether or not to select the project.

This method is very similar to the project selection method of Bo-flow, whereby the Dragons at Bo-flow can be seen as the Innovation Board by Nolsearch. However, there is also a clear difference. Namely, that Nolsearch keeps a clear continuous flow of projects through the Kanban method. So after a project is selected, it ends up in the Kanban and is only developed as soon as capacity and resources are available. At Bo-flow it is immediately picked up as a project, which has led that Bo-flow is working on many projects simultaneously.

On the 'one page' various aspects are mentioned with regard to the idea. This includes the following criteria for project selection:

*“.. what is the purpose of the project, what are the opportunities you identify, what type of project is it, on what aspects of our business model does it has influence, how is the project carried out, what are the deliverables, and what are the resources, preconditions, lead time and what budget you actually need to get started.”* – Product Manager Nolsearch (I10)

From this it can be interpreted that they take into account several different criteria. When the researcher asked in the interview which criteria they find important, there was no clear answer. The Product Manager (I10) indicated that they are still figuring it all out. The same applies for the independent or interdependent **assessment** of new product ideas. It happened independently before this new project selection method. However, the interview has shown that Nolsearch wants to go more towards an interdependent assessment, because the Product Manager (I10) thinks that much more can be achieved by using synergies between projects. But this has not yet been worked out properly.

When looking at the decision-making process of project selection at Nolsearch, it can be concluded that decision-making is based on both **rationality** and **intuition**. Before a project is selected, a lot of relevant information has already been researched, which has been elaborated in the 'one page'. The members of the Innovation Board discuss this from different perspectives, which creates a conscious choice. However, the predetermined goals are not well developed and therefore not yet clear to everyone.

*"I think that not everyone has the same clarity right now about the goals we pursue, but that is the starting point where we are working towards."* – Product Manager Nolsearch (I10)

The direction they take is therefore mainly based on intuition, or in other words, on the feelings and past experiences of the decision-makers.

Because Nolsearch just started with this project selection method, the informant (I10) could not say anything about **political behavior** within the decision-making process. If it occurs, the informant (I10) thinks it will be unconscious which makes sense, because someone, for example, fights harder for his own idea than for someone else's idea.

#### **4.1.5 Veprecise**

Veprecise creates new ideas for product innovations and their development in the technology department, also called R&D and application & engineering. The interview with the R&D Manager (I11) showed that Veprecise does not use a specific decision support system for selecting new projects, same as with Ntech. It is done through consultation with middle managers in the technology department, who have the ultimate **decision-making authority**,

unless the investment exceeds a certain amount, then the managing board will make the choice. Actually, it is just a matter of planning, according to the R&D Manager (I11):

*“In principle, it is just a planning system; you have so many hours available and you have reserved things in advance, all your projects that you run, you have to put in there, and what then remains is free for new ones.”* – R&D Manager Veprecise (I11)

At Veprecise they first look at the **capacity** of the employees and their available hours. If the capacity allows it and the project offers potential based on expected **reward**, the project will be selected.

*“We are here to make money. So in my opinion that should also be the most important criteria on which you place your project on the ranking.”* – R&D Manager Veprecise (I11)

In recent years, Veprecise has made a pre- and post-calculation of each project. Due to the knowledge gained from this, it is easier to predict projects (R&D Manager, I11), which means that the differences between the pre- and post-calculations are getting smaller for each project. In addition, the projects are **assessed** first independently of each other, afterwards they looked at the interdependencies. Why they do that explains the informant as follows:

*“We start looking at each project on its own. There is a challenge in that, that you do not have to make projects complex. Because if you have a project that only pays like that project this and that, then the success rate is already low. So we make it very simple, much cheaper and with a little less yield, but then you can see it as a nicely rounded whole. Eventually everything falls into place when dependencies arise.”* – R&D Manager (I11)

The informant (I11) indicates that the main goal of Veprecise is to achieve the best possible operating result. All projects that offer no potential to pursue that goal, so a bad pre-calculation, are not selected. This is a **rational** aspect of the decision-making process of Veprecise. In addition, the choices are supported by gathered relevant information. A tool that they use for this is a dashboard. The dashboard contains the following daily information:

*“.. you should know at any time of the day what free production capacity you still have. How good am I at this moment, what is the quality measure, what about my margins, do I serve my customers on time.”* – R&D Manager (I11)

From this it can be concluded that Veprecise has mainly implemented a rational decision-making process. The R&D Manager (I11) also mentioned that the dashboard is the cause for **intuition**. The explanation for this is when the daily information gives a good overview, it automatically leads to a good feeling (R&D Manager, I11). Furthermore, the interview showed that **political behavior** practices are low, because the pre- and post-calculation leaves little room for the pursuit of personal goals.

#### **4.1.6 PPA**

Compared to the other high-tech firms in this research, PPA has by far the least employees and is therefore considered the smallest firm. A big advantage according to the Accountmanager (I12) is that a small firm has better overview of all current activities, resources and capacity. In addition, PPA has developed an informal structure with short lines of communication between employees. Therefore, they do not need a decision support system for selecting new projects according to the Accountmanager (I12), but this is done by means of a three-man committee who has the **decision-making authority** and make decisions regarding project

selection during weekly meetings. This three-man committee consists of the managing director and two middle managers. During this meetings, projects are first **assessed** independently, but after that, PPA will try to benefit from mutual dependencies if possible. This corresponds to Bo-flow and Prowater. Compared with other high-tech firms included in this research, there is a relatively low presence of **political behavior** at PPA based on the following quote.

*“I do think that our political behavior is relatively low, especially when I compare it with larger firms. The interests here have not so much to do with internally growth, for example, you have more of that type of cases within large firms.”* – Accountmanager PPA (I12)

Based on this quote it can be concluded that political behavior mainly occurs because of personal interests and not personal goals, such as promotion. Thereby, the following quote describes the current decision-making process:

*“.. a delineation at strategy level, that is the rational side. That is a checklist where you have to check whether it meets all the strategic requirements. But we also include minimum expected turnover and margin on this. So I see that as a rational. And eventually we make the choice on intuition. So basically, we do the sticking rationally controlled, really on the basis of researched information and goals that we strive for, but intuition comes with the final choice.”* – Accountmanager PPA (I12)

Besides that this quote demonstrates that the decision-making process is based on a combination of both **rationality** and **intuition**, it also shows that they have drawn up several strategic requirements. PPA has defined a clear business strategy which all new projects must comply. The **strategy focus** is because of that one of the most important criteria. But, the financial picture concerning the expected **reward** must also be correct, according to the Account Manager (I12).

In contrast to the other firms, the Account Manager (I12) of PPA experiences no difficulties with project selection, while a major share of the informants view project selection as a complicated procedure. And that is because PPA has a good overview of daily activities, production, resources and capacity, something that Veprecise also does well.

#### **4.1.7 Spe-metal**

Like every firm discussed, Spe-metal also has its own type of project selection method. In this case, all requests for new projects are received by the R&D Manager (I13). The R&D Manager makes an estimate between the investment, costs, and what it can ultimately deliver. For this he also uses a master resource schedule, to see if it is actually possible.

*“We use a master resource schedule, so we know from every engineer what it is or is supposed to be at that moment and how many hours have been scheduled for that week for certain projects, so I can look ahead in the long term.”* – R&D Manager Spe-metal (I13)

An estimate of the expected **reward** together with an overview of the available **capacity** are the most important criteria that projects must meet, according to the informant (I13). When asked in the interview whether new product idea **assessment** happens independently or interdependently, the R&D Manager (I13) answered that they were doing it interdependently, but he added the following:

*“I think that as a firm you can get a lot more out of that. In this way you can create added value.”* – R&D Manager Spe-metal (I13)

Thus, the R&D manager presents the plans to the managing board who has the **decision-making authority** with regard to selecting or not selecting projects. This happens during biweekly meetings. The R&D Manager (I13) thinks it is positive that the managing board has the decision-making authority, because this group is diverse in which all top managers have their own qualities and look at a project from different angles.

About the decision-making process the informant mentioned the following:

*"In some cases you must be able to let go of that rationality at a certain point, which is a part of me I also take with me from my past, a piece of entrepreneurship, that I dare to take that risk."* – R&D Manager Spe-metal (I13)

From this can be concluded that both the **rational** aspect and the **intuitive** aspect play a role in making decisions about project selection. The gathering of information and the pursuit of goals is done in a rational way; however, the pre-calculation of a project does involve feeling and past experience. As the R&D Manager (I13) calls it: entrepreneurship. Furthermore, as emerged from the interviews, the presence of **political behavior** is the same within Spe-metal as within Ntech. Because several people with different disciplines take decisions together, there is hardly any room for political behavior.

#### 4.2 Effectiveness of current project selection practices

This paragraph deals with answering the second part of sub-question 2: *What are the current practices in different high-tech firms concerning their project selection in terms of effectiveness?* The four goals of Cooper et al. (2001) are used in this study as a measure of effectiveness of a project selection method.

To begin, table 6 shows the extent to which each high-tech firm meets the four goals of effectiveness. More specifically, a project selection method is the most effective when a firm meets all four goals.

	Strategic alignment	Maximize value	Balanced portfolio	Right number of projects
Bo-flow	Low	Medium	High	Low
Ntech	High	Low	High	Low
Prowater	Medium	High	Medium	Medium
Nolsearch	Medium	Medium	High	Medium
Veprecise	High	High	High	Medium
PPA	High	High	Medium	High
Spe-metal	High	High	Medium	Medium

Table 6: Current state of effectiveness in high-tech firms

Strategic alignment means the extent to which the projects in the portfolio are linked to and underset the business strategy. As table 6 shows, Bo-flow's portfolio is the least linked to the business strategy compared to the other high-tech firms. When a high-tech firm scores high at maximal value, the expected financial value criterion has been of great importance in the selection of projects in recent years. A balanced portfolio means that the firm's overall risk is well spread over a mixed combination of projects. And an high measurement of PPA on the right number of projects means that they have realized a well consideration between available resources and projects compared to the other firms.

In order to include the characteristics of project selection methods described in previous sections, table 7 shows the high-tech firms ranked on the basis of effectiveness and what characteristics they possess. The two firms ranked in 1. are the ones that meet the four goals of effectiveness the most, with the most ‘high’ measurements, while Bo-flow has the least effective project selection method. This ranking provides more clarity about which characteristics occur in the most effective project selection methods. The specific relationships that have been discovered between characteristics and the four goals of effectiveness are mentioned in paragraph 4.3.

		Rationality/ intuition	Political behavior	Top-down/ bottom-up	Independent/ interdependent	Most important criteria
1.	Veprecise	Both	Low	Both	Both	Capacity & reward
1.	PPA	Both	Low	Both	Both	Strategy & reward
2.	Spe-metal	Both	Low	Top-down	Interdependent	Capacity & reward
3.	Prowater	Both	-	Top-down	Both	Strategy, effort, risk & reward
3.	Nolsearch	Both	-	Both	Interdependent	-
4.	Ntech	Both	Low	Bottom-up	Independent	Effort/impact & strategy
5.	Bo-flow	Both	Medium	Top-down	Both	-

Table 7: Ranked high-tech firms and characteristics of project selection

The effectiveness measurements of each high-tech firm’s project selection method are explained in more detail in the following sections.

#### 4.2.1 Strategic alignment

It appears that about half of the informants find strategic alignment the most important effectiveness goal for project selection.

*“I think that is the most important thing. If you do something that does not suit your firm, what are you doing then?” – Project Manager Ntechn (I8)*

Doing things that suit the firm is one of the most important thoughts, that has been proven. The results of the interviews have also shown that the majority of projects within high-tech firms are linked to the business strategy of those firms, but that it still can be improved.

The interviews pointed out that the portfolio of Ntech, Veprecise, PPA and Spe-metal are closely linked to the business strategy due to a concrete and clearly defined business strategy.

*“I think the most important thing is that as a firm you draw a single line. Clarity, transparency. And I think you should really put these things down on paper, even if you only work out what's in your head, including communication. Make sure you know where you want to go.” – Accountmanager PPA (I12)*

If a few projects are not strategically linked, then that is a result of old projects that are considered as an aftermath, according to the R&D Manager (I13) of Spe-metal, or that a project was favourable for the short term (Account Manager PPA, I12). At Prowater and Nolsearch the strategic alignment can be improved. The business strategy at Nolsearch is not yet clear enough and Prowater’s local business strategy does not fit with the global one. As a result, a part of the current portfolio does not match with the business strategy. At Bo-flow, the strategic alignment is really low compared to other high-tech firms. The reason for this is that it appears that many informants are not entirely satisfied with the clarity and concreteness of the firms’ business strategy. An informant said about the business strategy of Bo-flow the following:

*“He is clear in itself, but he is too broad to get a lot out of it. The slogan ‘we do low flow fluidics handling’ gives a bit of an indication, but there is still some room. We also continuously confront the managing director about this.” – Manager R&D Bo-flow (I4)*

The informants indicated that they find it difficult to elaborate a clear business strategy for high-tech firms. This is because many high-tech firms want to realize innovation and therefore often want to do too many things that are probably just beyond the strategy, to show being innovative to the outside world. An informant said about this:

*“But the strategy is actually, that by means of innovation we also want to serve our customers as much as possible. The emphasis is also on innovation, which is actually the only small game in this big market where we can stand out from the crowd.” – R&D Manager Spe-metal (I13)*

It is therefore of great importance to define a business strategy well and concrete, so that all members in a firm know what goals should be pursued. In addition, a well-defined concrete strategy makes it easier to assess projects for a strategic fit.

*“I think that in the selection process you need to have a clear vision of the goals you pursue. For example, we have chosen to focus on certain market segments. You have to keep that in mind when selecting new projects.” – Manager Product Marketing Prowater (I9)*

#### **4.2.2 Maximize value**

In addition to strategic alignment, it has become clear that realizing a maximum attainable portfolio value is also very important. The maximum value of a portfolio is difficult to measure, because it is impossible to know what it would have been like if a firm had selected other projects. Therefore, the maximum feasible value of a portfolio is measured in this research on the basis of a decision criteria that forms the basis for selecting a new project, namely the expected financial value or reward. From the interviews it can be concluded that all high-tech firms assess projects on the basis of an expected value and use this as a decision criteria, but that each firm has implemented this in its own way. However, the question is whether projects are ultimately selected for high expected value or whether other decision criteria are more important?

Both informants of Ntech think it is more important that projects fit the business strategy than using the expected value as decision criteria. An high expected value is therefore not an important condition for a new project.

*“We are much more concerned with what is strategically wise to do. Because if we know that in five years’ time we still want to go with that product to certain customers, then we have to go for it. And not for something that seems interesting today, financially speaking.” – Project Leader Ntech (I8)*

At Bo-flow and Nolsearch the informants see it as an important condition, but they have not been able to use this properly. Until now, it mainly happens on wishful thinking. Prowater, Veprecise, PPA and Spe-metal use expected value as an important decision criteria and have their own calculations to assess this. Prowater uses for example the ROI calculation; return on investment. Spe-metal makes a cost-benefit analysis and Veprecise makes both a pre- and post-calculation with regard to a project's value, while PPA looks at the payback period of a project. From the interviews it emerged that two aspects influence the maximization of the value of a portfolio. The first aspect is to have a good understanding of how your firm is doing.

*“I think it is important to know where you stand and what you want to achieve with your firm.”* – Product Manager Nolsearch (I10)

*“I think the art of that is, that you have to have a very good picture of where your firm stands for.”* – R&D Manager Veprecise (I11)

Veprecise realizes this by keeping an online dashboard up to date. The QCD systematics are mentioned on the dashboard; quality, cost and delivery. Because of this, everyone knows what is going on, what possibilities there are and how much space there is left, so that, for example, not too many projects are developed that ultimately do not yield the value that was expected in advance. The second aspect has to deal with the strategy of a firm. The following quote clearly explains that:

*“That also has to do with the strategy, where do you want to go, your annual plan, what you want to achieve on the short and long term. If you now choose to, for example, take a new route by ‘opening’ or entering a new market, then you know that you do not immediately earn that back. Then you have to accept that the turnover is less, and later, if the turnover is better, more.”* – Product Manager Ntech (I7)

In the following quote, both aspects are mentioned:

*“I think it is important to know what your position is and what you want to achieve with your firm. Which mission and vision you want to pursue.”* – Product Manager Nolsearch (I10)

From these quotes, it can be interpreted that the type of strategy that is being made at the corporate level plays a major role in achieving a maximize portfolio value. A corporate strategy deals with the overall objective and scope of a firm (Bowman & Helfat, 2001), and these strategic choices influence the value that is achieved, because when a firm chooses to enter a new market, the firm must be taken into account that the results are not yet sufficiently good in the short term that a maximal value can be achieved.

#### **4.2.3 *Balanced portfolio***

The third goal of effectiveness is measured in this research by the balance of a portfolio in terms of risk spreading. The interviews have shown that the balance is reasonably good in the portfolios of the included high-tech firms. Especially for Bo-flow, Ntech, Nolsearch and Veprecise. Bo-flow has a large product range and they also operate in many different markets worldwide, which means they have spread the risk well.

*“We have a universal product, so the more spreading you have in your markets, the more spreading you have in your customers, the more customers you have, the less vulnerable you will be to setbacks in one of those markets. Bo-flow is already very well diversified, so I do not worry about that.”* – Managing Director Bo-flow (I3)

Based on the website of Ntech, Ntech operates with its technology in many different markets. Not only globally, but also the type of industry varies. This means that Ntech has also spread its risk well through a mixed combination of projects. The two informants of Ntech confirmed this. The interviews with the Product Manager of Nolsearch (I10) and the R&D Manager of Veprecise (I11) showed that their firms have also a spread in the overall risk, partly thanks to the different types of projects and the different markets. In addition, they make a clear distinction between incremental, really new and radical projects. For Prowater, PPA and Spe-metal, the risk is relatively less spread. Prowater and Spe-metal operate in different markets,

but especially with the same product. It is possible to make adjustments for a specific customer; however, it is not that they have a large product range. The spread of risk is mainly because of the various markets worldwide and the long and short-term projects, as shown in the interviews. The interview with the Accountmanager of PPA (I12) has shown that the balance is already there, but that they are still working towards the right balance.

*"I have to put a nuance in that, we are very much concerned about that balance, because that is also part of our strategy, which we want very much, but I must indicate that we have that balance not yet integrated for 100%."* – Accountmanager PPA (I12)

From this quote, it can be concluded that this also has to do with the age of the firm. PPA is by far the youngest firm, founded in 2013, compared to the other high-tech firms included in this research. The other firms have already created that balance reasonably well over the years, but because PPA has not been operating for such a long time, they are still on their way to realize this balance of risk spreading.

As with the previous goal of effectiveness, maximize value, it has also been shown here that the type of corporate strategy influences the balance of a portfolio. The following quotes support this conclusion:

*"I think that has to do with the markets you want to be in. What choices you have made with regard to your strategy. We clearly stated a time ago and agreed which way we want to go, in which market segments we want to be, and that includes a bit of risk spreading."* – Manager Product Marketing Prowater (I9)

*"They also have to be clear about what that balance should be, with goals attached to it, so include that in your method or system that you use for that."* – Accountmanager PPA (I12)

#### **4.2.4 Right number of projects**

Creating a good balance between available resources and projects is important for innovative firms, in other words, picking the right number of projects. The interviews showed that all included high-tech firms have problems with a lack of resources, mainly people with technological knowledge are in great demand.

*"We notice that the market is doing well right now. So that it is difficult to get new people. There is a lot of competition."* – R&D Manager Veprecise (I11)

However, the question is to what extent they have made a good balance between the available resources and the projects. The two firms that have managed this balance least well are Bo-flow and Ntech.

*"Far too many projects, far too much."* – Product Manager Analyst Bo-flow (I5)

*"At the moment we are really having a problem, we are really looking for new people."* – Project Manager Ntech (I8)

The balance is hard to find. The reason for this is that at Bo-flow everyone said yes to new product ideas. Projects were approved just because no specific procedure existed. At Ntech they find it difficult to manage the combination between customer maintenance and new customers, which means that they are now running short of resources for maintenance, something that was not expected in advance. Shown by the interviews is that Prowater, Nolsearch, Veprecise and Spe-metal also experience a lack of resources, but they have managed the balance more careful.

*"We let go what we can, and we also dare to say 'no' if our capacity does not allow it." – Manager Product Marketing Prowater (I9)*

Another informant said the following:

*"We use a master resource schedule, where we know what each engineer is or is supposed to be at that moment and how many hours have been scheduled for that week for certain projects, so I can anticipate this in the long term. see and create a good balance." – R&D Manager Spe-metal (I13)*

The exception is PPA, they sometimes experience a lack of resources, but that is often afterwards because the effort is different than expected in advance.

*"I think that, of the four portfolio goals that you are talking about, we are focusing the least on this, and sometimes run into it afterwards." – Accountmanager PPA (I12)*

However, PPA does have a clear overview of the human capacity, because of the small number of people employed. Therefore, they know every day which resources are available and when there is free capacity. This leads to a well-considered balance between available resources and projects. Hereby can be concluded that a good understanding of the current state of affairs, with regard to resources and capacity, is of great importance for creating this balance. The following quotes support this conclusion:

*"I think that this mainly has to do with the knowledge you have about the current affairs of the firm you work for. I mean that you have to clearly map out what the planning looks like, who works when, how much time it takes, etc." – Product Manager Nolsearch (I10)*

*"It makes it easier to get that balance when you clearly understand what your resources are and whether there is still time available for a new project." – Manager Product Marketing Prowater (I9)*

In conclusion, rational aspects play a major role in achieving the four goals of effectiveness due to the fact that it is important for high-tech firms to gather substantiated knowledge about the current state of affairs and to define a concrete business strategy with associated goals. These aspects help a firm to realize the four goals of effectiveness and are therefore of great importance. However, these aspects stand outside a project selection method and cannot be interpreted as characteristics that belong to the decision-making process or the assessment of new product ideas within such method. The characteristics that do belong to a project selection method come forward in the next paragraph in which the relations are discussed with the four goals of effectiveness.

### **4.3 Characteristics of project selection methods and effectiveness**

In this paragraph, the relationships between characteristics and effectiveness are discussed in more detail. This answers sub-question 3: *How are different characteristics of project selection methods related to effectiveness in different high-tech firms?*

#### **4.3.1 Relationships between decision-making characteristics and effectiveness**

The much-discussed decision-making characteristics in this research are **rationality** and **intuition**. All informants have indicated that these two characteristics interact with each other and that they play a role together when making choices. These choices are not only about selecting projects, but also choices that are related to other decision-making activities, such as

gathering information, assessing new product ideas, weighting of criteria and selecting projects.

Combining rationality and intuition in the decision-making process allows these two characteristics to reinforce each other until an optimal choice can be made that conforms with both rationality and feelings/experiences. For example, the R&D Manager of Bo-flow (I4) mentioned that they use a scoring model as a rational analysis to assess projects, but ultimately they listen also to the intuition of decision-makers to comprehend a decision more fully.

The following quotes illustrate the combination of rationality and intuition:

*"I think gut feeling plays a role especially in the initial phase of the ideas, but the further you come, you have to measure and experiment, and that involves more rationality."* – Product Manager Nolsearch (I10)

*"So basically, we are staging the framework in a rational way, really on the basis of investigated information and goals that we strive for, but intuition does come with the final choice."* – Accountmanager PPA (I12)

These quotes immediately show that the relationship between intuition and rationality may work generally in two ways. First, proceeding from intuition to rationality implies a process in which decision-makers first use their intuition as an idea explorer, and afterwards they use their rationality to build the idea. Second, moving from rationality to intuition indicates a process in which decision-makers substantiate and base their choice on a rational foundation, and then they use their intuition to check this rationality and make the final decision. In other words, rationality and intuition are complementary to each other what can be expressed in two ways. This leads to the conclusion that decision-makers need to take into account both rational analysis and intuition in decision-making situations. Because, intuition is not an independent process operating without rational analyses. The R&D Manager of Veprecise (I11) describes this by saying that investigated information is nutrition for gut feeling. So, a certain feeling arises on the basis of information and knowledge or experience that a person already possesses. And the other way around, certain information is better examined and substantiated when someone feels good about it. These reasons show that the combination positively influences every decision-making process, which ensures that the choices are well-founded, both rationally and intuitively. These well-founded choices influence each goal of effectiveness, based on where the decision is about and what goals a firm strives for, in a positive way. This suggests the following propositions:

*Proposition 1a: Rationality and intuition are complementary to each other in decision-making processes*

*Proposition 1b: Taking into account both rationality and intuition in decision-making processes positively influences all four goals of effectiveness*

The interviews have pointed out that there is no unambiguous relationship between the characteristic **political behavior** and the four goals of effectiveness. Opinions of the informants differ. The Manager Product Marketing of Prowater (I9) for example thinks that political behavior does not have a bad influence at all, because personal goals and interests are always in line with business goals. But the Product Manager of Nolsearch (I10) believes that firms should try to suppress political behavior as much as possible, because otherwise it leads to

mutual division. So, unfortunately, no conclusion can be drawn as to whether or not political behavior leads to effectiveness.

Additionally, the interviews have shown that another decision-making characteristic has a relationship with one of the four goals of effectiveness, namely the **decision-making authority**. As is shown in the previous paragraph, some high-tech firms use a top-down approach, others a bottom-up approach and even others use a combination. It is very diverse, so it is difficult to clearly indicate which approach will most likely lead to effectiveness. Several informants have indicated that middle managers are the closest to a product and therefore know the technological aspects best. Therefore, they can better estimate how a technology can be developed and what risks are involved.

*"Only people who are more involved in a project, who can, certainly on technological aspects, have a better view, and I think you can basically trust on that."* – Product Manager Analyst Bo-flow (I5)

In addition, other informants said that it depends on the business strategy. The following quote illustrates this:

*"It depends a bit on what kind of firm it is, if the strategy is very focused on quality and technology, top managers cannot do it alone, so they have to take the knowledge of other people into account."* – Accountmanager PPA (I12)

As described in chapter 2, the business strategy is how to compete within a particular business, whereby this task often lies with the middle managers, while the top managers have the task to fill in the corporate strategy. From this it can be concluded that a bottom-up approach will lead more to a link between new projects and the business strategy, which is one of the goals of effectiveness; strategic alignment of the portfolio. This suggests the following proposition:

*Proposition 2: In comparison with the decision-making authority top-down, a bottom-up approach leads more to a positive influence on the strategic alignment of a portfolio*

The **decision-making authority** has a second relationship with effectiveness. And this time with all four goals of effectiveness. It has been shown from the interviews with the informants that everyone is an advocate of a group of people with different disciplines who make final decisions regarding project selection together. The two following quotes illustrate this:

*"If those different people with disciplines are together, it is almost impossible to aim for your own gain, but rather for the organization wide."* – Project Leader Ntech (I8)

And another informant said about this:

*"The managing board is also very diverse, not only in terms of disciplines, but also in terms of mentality, and as a result, political behavior is well tempered."* – R&D Manager Spe-metal (I13)

The previous examples show that when several people with different disciplines have the decision-making authority, new product ideas are viewed from different angles and this influences decision-making processes in a positive way. In addition, the possibility of political behavior is less. It only depends on which goal or goals a firm wishes to pursue, but it can have a positive effect on every goal, as long as a diverse group with different disciplines has the decision-making authority. This suggests the following proposition:

*Proposition 3: A group of people with different disciplines who have the decision-making authority positively influences all four goals of effectiveness*

#### **4.3.2 Relationships between scoring characteristics and effectiveness**

The first scoring characteristics included in this study is **the assessment of new product ideas** independently and/or interdependently. All high-tech firms, except Ntech, assess projects both independently and interdependently, or only interdependently. The R&D Manager of Spemetal (I13) sees interdependent assessment as a way to create added value compared to competitors. From the interviews it emerged that when the informants speak about interdependencies, then they mainly mean synergies between projects, such as knowledge benefits. The following quotes describe this:

*"At first we look independent, but hereafter we work mutually. We do not want to put our investments on one customer, but we want to use developed techniques also to serve other customers, or use them in other projects."* – Accountmanager PPA (I12)

And another quote underpins this:

*"So if you put the same team on a project, then you can use that knowledge which you learn on this project directly in another project. So that is also true for resources. But the aim is to be aware of that kind of synergies and to deal with it."* – Product Manager Analyst Bo-flow (I5)

In the independent assessment of new product ideas, ideas are individually assessed as separate projects, however, no proof was found for a relationship with one of the goals of effectiveness. In contrast to an interdependent assessment. As the above quotes show, much more is taken into account in interdependent assessment, such as the impact that a new project can have on the resources of other new or existing projects.

*"You always have to think about the influence that a project has on resources, for example, on another project, so we do take that into account."* – Product Manager Ntech (I7)

From this, it can be concluded that the interdependent assessment of new product ideas therefore leads to more balance between available resources and projects in comparison with independent assessment. In other words, it influences picking the right number of projects, which is one of the goals of effectiveness. This suggests the following proposition:

*Proposition 4: An interdependent new product idea assessment positively influences the right number of projects in a portfolio*

The other scoring characteristic means whether a firm uses the **weighting of criteria** or that all used criteria are equally important. All high-tech firms included in this research use the weighting of criteria, so each firm has set certain criteria that are more important than others. Even though no proof has been found for the most important criteria for Bo-flow and Nolsearch, the informants of those firms have indicated that they are working on it and will use weighting of criteria in the future. But why do firms weigh criteria? The interviews clearly showed that this has to do with which direction a firm wants to go, as the following quotes explain clearly:

*"I think that has to do with which direction you want to go as a firm, so which strategy do you have and what goals do you want to achieve? And that includes criteria that are more important than others."* – Product Manager Nolsearch (I10)

The following informant added:

*"This has to do with what you want as a firm, how you want that others see you and what organizational goals are attached to it, and I think that is only good for selecting new ideas so that they fit in well with your firm. That's what it's all about."*

– Accountmanager PPA (I12)

From this it can be concluded that certain criteria weigh more than others depending on the goals that are being pursued. As mentioned earlier, the different decision criteria that belong to content characteristics are used by high-tech firms to assess projects in order to reach their goals. Therefore, the weighting of criteria influences the use of content characteristics. This suggests the following proposition:

*Proposition 5: The weighting of criteria influences the use of decision criteria which belong to content characteristics*

#### **4.3.3 Relationships between content characteristics and effectiveness**

Prior to the interviews, four content characteristics from the literature review were discussed. But as described in 4.1, two additional content characteristics have been discovered that are considered important by the informants. The six content characteristics are: (1) strategy focus, (2) market attractiveness, (3) risk, (4) reward, (5) capacity and (6) effort. During the interviews, the informants were asked where they thought certain content characteristics would lead to when high-tech firms use these as decision criteria. In order to prevent bias, the relationships are not specifically named by the researcher, which means that there may be some more relationships that have not been discovered in this research. The relationships that have been discovered between these characteristics and the four goals of effectiveness are described consecutively.

First, a relationship has been discovered between the use of **strategy focus** as criteria for selecting projects and one goal of effectiveness; the strategic alignment.

*"When you select projects based on strategic criteria, I think it will automatically lead to a better fit that we talked about earlier."* – Product Manager Bo-flow (I6)

Another quote that emphasizes this relationship:

*"And following the strategy by using it as criteria ensures that we do projects that suit us."* – Accountmanager PPA (I12)

From these quotes it can be clearly interpreted that when high-tech firms use a strategy focus as criteria, for example by drawing up a checklist or scoring model with strategic points that a project must meet, this will benefit the strategic alignment of the firm's portfolio. No relationship has been discovered with the other three goals of effectiveness. This suggests the following proposition:

*Proposition 6: The use of strategy focus as decision criteria positively influences the strategic alignment of a portfolio*

Second, the use of **market attractiveness** as criteria does have an influence on one of the goals of effectiveness. About half of the informants do not consider market attractiveness as an important decision criteria for selecting projects, because they believe that market attractiveness mainly plays a role in choosing and defining the strategy.

*"With market attractiveness, you see which priorities you have, in which technologies you really want to be good at, where you want to excel, which are the edge products, so the strategy is emphasized in this." – Project Leader R&D Bo-flow (I1)*

The other half of the informants mentioned, however, that their firms do market research into the attractiveness. The reason for this is that these firms only want to develop new products or modifications to products that already have a commitment from customers, so that the firm is sure that there is a customer need.

*"Ideally, you already have a certain commitment from the market, so if you know a customer that offers real security that they want to buy." – Product Manager Bo-flow (I6)*

*"You do not choose an idea that has no demand at all, which does not create a good portfolio value." – Product Manager Nolsearch (I10)*

Commitment provides firms more certainty for the sale of a product, which contributes to the realization of a maximal value of the portfolio. This suggests the following proposition:

*Proposition 7: The use of market attractiveness as decision criteria positively influences the maximization of a portfolio's value*

Third, the discovered relationship between the use of **risk** of a new project as decision criteria and one of the four goals of effectiveness is suggested here. The informants have different opinions about the importance of the criteria risk. One informant thinks it is very important because it provides an idea of the extent to which the expected reward can be achieved (R&D Manager Bo-flow, I4), but another informant said that the prediction of risk is so difficult that it has no value (Project Manager Ntech, I8). The question is actually; where can the use of risk as criteria within project selection lead to? The following informant gives an answer:

*"I think that a firm cannot survive without a reward, and the risk actually predicts the extent to which this reward can be achieved, so it is extremely important. Technology is changing so fast. There are more and more technological changes that you can apply and need to apply within our field and, on the other hand, there are also more and more business models that can be disruptive, and with that risk you are more likely to be involved." – Product Manager Nolsearch (I10)*

The informants of Prowater and Spe-metal also emphasize clearly that taking risk into account as decision criteria leads to maximize the value of the portfolio. Thus, the following proposition is suggested:

*Proposition 8: The use of risk as decision criteria positively influences the maximization of a portfolio's value*

Fourth, the most logical relationship that was predicted in advance is discussed here, which is the use of the expected **reward** as criteria and the achievement of a maximum value of the portfolio. In the interviews this relationship has clearly emerged, without having specifically named this relationship by the researcher. The following quotes serve as proof for this relationship:

*"That is actually the most important task that we have been receiving by the managing director: financial growth. So you should be able to express all the choices you make, if possible, in reward." – Product Manager Analyst (I5)*

*"Risk and reward, think logically, lead to the maximum achievable value." – Manager Product Marketing Prowater (I9)*

These examples suggest the following proposition:

*Proposition 9: The use of reward as decision criteria positively influences the maximization of a portfolio's value*

The fifth discovered relationship is about a content characteristic which has been found in the interviews, namely **capacity**. Using the capacity as criteria experience the informants as very important, for different reasons. Prowater and Ntech see capacity as an obstacle. When there is no more capacity, no new project can be selected. However, another informant said the following about this:

*"... the way we react to it is simple: more demand means making more capacity available." – R&D Manager Veprecise (I11)*

In some branches it is easier to temporarily hire workers than in other branches where more specific knowledge is required, such as Bo-flow. Nevertheless, capacity plays a role everywhere when selecting new projects. The interviews have shown that it influences one goal of effectiveness. According to the Product Manager of Prowater (I9), this leads to a better balance between resources and projects, in other words, picking the right number of projects. As stated in 4.2.4, the knowledge about the current state of affairs of the firm positively influences the balance between available resources and projects, and in particular it is knowledge about the capacity of a firm. The following quote illustrates this:

*"It is really a trade-off that we make based on available capacities at that moment, but you have to be transparent about that, even for the long term." – R&D Manager Spe-metal (I13)*

This suggests the following proposition:

*Proposition 10: The use of capacity as decision criteria positively influences the right number of projects in a portfolio*

And the last discovered relationships have to do with **effort**, which has also been found in the interviews. The interviews have pointed out that effort has a positive influence on two of the goals of effectiveness. The first relationship is emerged with the maximization of a portfolio's value:

*"It is a mix of what it is going to deliver, where it is important how much time and effort it costs us." – Product Manager Bo-flow (I6)*

Portfolio value has not only to do with how much a project will deliver, but also with the effort that is needed to realize this. This indicates that the more effort, the less commercial value in the end. However, the relationship is not about the effort itself, but about the use of effort as decision criteria, and that has a positive influence on the maximization of the portfolio value. This also applies to the second relationship with another goal of effectiveness, namely the right number of projects in a portfolio. According to the informants, the inclusion of effort as decision criteria ensures a better balance between available resources and projects. Therefore, the following propositions are suggested:

*Proposition 11a: The use of effort as decision criteria positively influences the maximization of a portfolio's value*

*Proposition 11b: The use of effort as decision criteria positively influences the right number of projects in a portfolio*

The aforementioned propositions are illustrated in the conceptual model below.

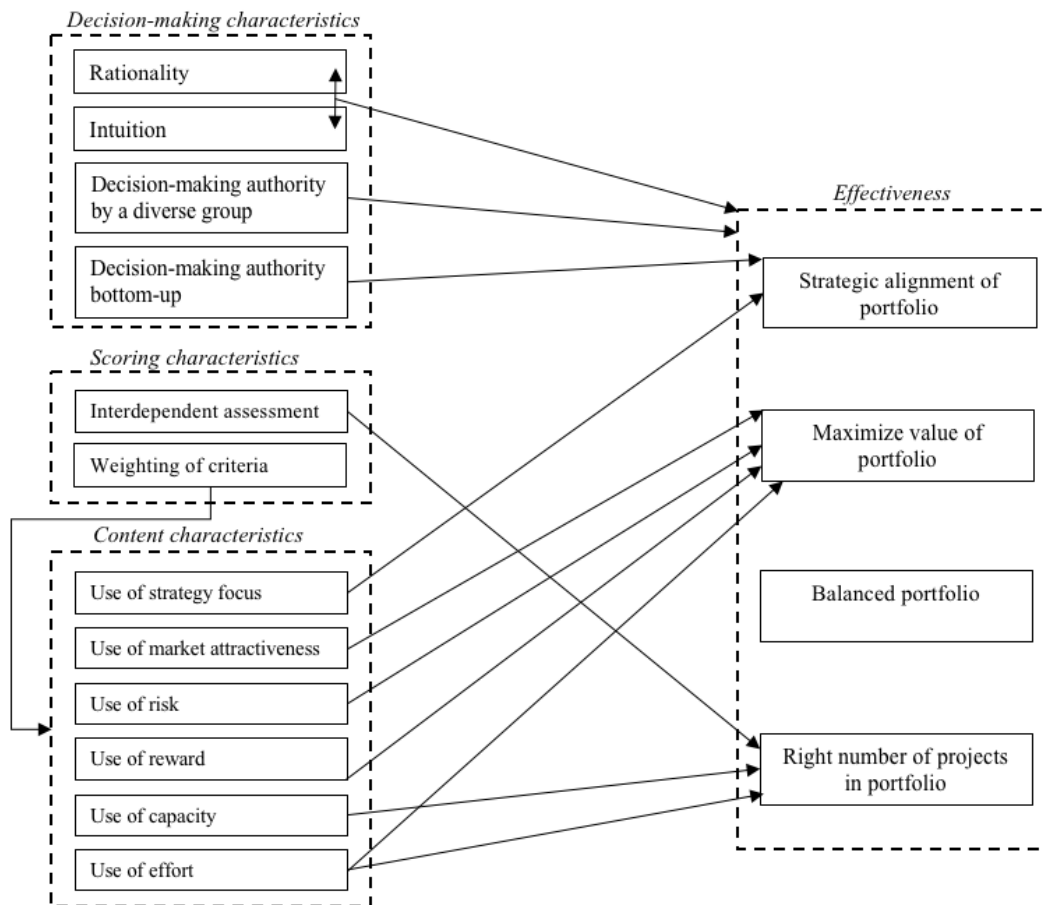


Figure 9: Conceptual model relationships

The conceptual model show that all characteristics have their own influence on one or more of the goals of effectiveness. In conclusion, the decision criteria that high-tech firms find most important depends on the strategy and the goals they pursue. Furthermore, the maximization of a portfolio's value is most influenced by a large part of the content characteristics. A reasoning for this is that a major share of the informants finds it the most important to strive for the highest possible commercial value. Two quotes from the same informant illustrate this:

*"But the bottom line is simply to make more sales."*

*"The operating result is the only thing you do it for."*

– R&D Manager Veprecise (I11)

Another conclusion that can be made is that no characteristic affects the achievement of a balanced portfolio. The most likely reason for this is described in 4.2.3, which is that the interviewed high-tech firms are matured, in consequence that the balance in their portfolios has already largely been achieved. As a result, the informants have not considered this balance important and therefore, probably, no relationships have been discovered with this goal of effectiveness.

#### 4.4 The innovativeness of new product ideas as moderating effect

This last paragraph deals with the moderating effect of the innovativeness of new product ideas and create an answer on the fourth sub-question: *How does the difference between radical, really new and incremental product innovation influence the effectiveness of project selection methods?* In other words, does the innovativeness of new product ideas – radical, really new and incremental product innovation – ensure that the relationship between characteristics of a project selection method and effectiveness changes? The answer is partly yes. More specifically, not for all relationships a moderating effect has been discovered.

First of all, it has been found that the innovativeness of new product ideas does have an influence on the relationship between **rational/intuitive** decision-making and effectiveness. The Product Manager of Ntech (I7) mentioned that the cause of this effect has to do with expectation management, whereby radical product innovations are much more difficult to predict. Radical product innovation contains both a marketing discontinuity and a technology discontinuity on the macrolevel, which are often based on technology push according to the Managing Director of Bo-flow (I3), and this includes more uncertainty about whether customers do need and want such particular innovation. According to the informants, this uncertainty leads to more involvement of intuition. Therefore, radical innovations are less substantiated and more uncertain, as a result of which intuition plays a greater role than with really new and incremental innovations consecutively. Really new innovations, and especially incremental innovations, are less insecure because more knowledge is available due to the fact that it mainly concerns micro discontinuities. The following quote argues this:

*"As you get closer, repeating something you have already done, the quality of the prediction you can make about it is also higher, because what deviates from what you already know is only very small. If you are going to do something totally new, then you have no reference, so by definition it is more insecure. It is always less rational when it is newer for you, which is not bad. But it includes more sense of feeling, because you have no facts."* – R&D Manager Verprecise (I11)

The other informants all agree here, including the following informant:

*"I think you would theoretically say that intuition is the biggest in radical projects, because you know little with just an idea that you feel you could work with. And with incremental information you already have the most information. So there you could do the most on the basis of ratio."* – Product Manager Nolsearch (I10)

These quotes describe that with incremental new product ideas the most rational analysis can be executed to use as foundation for selecting a project. Given these points, intuition plays the biggest role in radical new product ideas and the least role in incremental ones, while rationality plays the biggest role in incremental product ideas and the least role in radial ones. This suggests the following proposition:

*Proposition 12a: The relationship between rational/intuitive decision-making and effectiveness is influenced by the innovativeness of new product ideas*

Furthermore, the interviews have pointed out that a second moderating effect has been discovered between the **level of decision-making authority** and effectiveness. Two informants state that there is no effect due to the reason that it must be clear who has the decision-making authority and that this should be the same for all types of innovations.

However, the rest of the informants indicate that it will be most effective to pursue the four goals by leaving the decision-making authority to top managers with radical innovations, while in the case of incremental innovations the middle managers can be responsible. In really new innovations, a combination is possible, depending on the uncertainties it entails. The following quote illustrates this:

*"Incremental innovations can easily be left over to product managers, because there is less risk involved. And radical projects, that is how you will develop new technology, which includes a lot more responsibility, so the top management needs to be more involved."* – Product Manager Analyst Bo-flow (I5)

The R&D Manager of Verprecise (I11) agrees and adds that it depends not only on the risk and uncertainty, but also on the 'price tag' that is often higher for radical innovations than for real new and incremental innovations. However, the informants do indicate that the decision-makers have to listen to the input from the other management layer, because the more different disciplines, the more substantiated the decision. The below suggested proposition shows this moderating effect:

*Proposition 12b: The relationship between the level of decision-making authority and effectiveness is influenced by the innovativeness of new product ideas*

Although clearly requested in the interviews, it pointed out that the innovativeness of new product ideas has no moderating effect on the relationship between **political behavior** and effectiveness. The following quote substantiates this:

*"It does not depend on the innovation level, but on the individuals and their own interests."* – R&D Manager Spe-metal (I13)

Additionally, for both scoring characteristics, the idea assessment and the weighting of criteria, no moderating effect of the innovativeness of new product ideas has been found on their relationship with effectiveness. These characteristics demonstrate how the assessment of new product ideas is executed, and the interviews have shown that for every idea, regardless of the innovativeness, it happens the same.

*"I think that does not matter, it is not that we assess radical things differently than, for example, incremental. I do not think that this will lead to a different effectiveness if you assess these projects differently."* – Accountmanager PPA (I12)

Finally, the results of a possible moderating effect on the relationships between content characteristics and effectiveness are discussed. One informant is clear about this:

*"I think it is most effective if you assess all types of projects on the basis of the same criteria, in this way you create the most unification and the predetermined goals are best pursued, I think."* – Manager Product Marketing Prowater (I9)

For the criteria **market attractiveness**, **reward**, **capacity** and **effort**, a major share of the other informants agree. For example, one informant of Bo-flow mentioned about reward the following:

*"If you know how to express everything in sales, then it is by far the easiest to compare projects, both for incremental, really new and radical, and I think you should strive for that as a firm."* – Product Manager Analyst Bo-flow (I5)

However, the informants have different opinions about the criteria **strategy focus**. The informants of Ntech, Prowater and some of Bo-flow think that firms have to assess all types of projects, regardless of innovativeness, on the basis of the same strategic criteria. It is about

whether it really fits the firm and whether it helps to achieve the strategic goals. But, the Product Manager Analyst of Bo-flow (I5) believes that the strategy focus with radical innovations must be abandoned more, because otherwise it is an obstacle. He also said that incremental innovations must be in line with the strategy. The Product Manager or Nolsearch (I10) indicates the opposite, namely:

*"I think you should look more at the strategy when it comes to radical things, whether it really suits us, and whether that can achieve our mission, which is more important than with minor improvements and/or extensions to an existing product. Incremental adjustments a more familiar application."* – Product Manager Nolsearch (I10)

The answers are contradictory and do not overlap with each other, as a result that no statement can be made about a possible moderating effect. More specifically, no sufficient evidence has been found for an effect.

Nevertheless, one moderating effect has been found on the relationship between a content characteristic, **risk**, and effectiveness. This could be explained by the informants who indicate that risk must be used in different ways in radical, really new and incremental innovations in order to realize an effective project selection method.

*"Incremental is much more easier to plan, because it is an improvement or something, there are fewer surprises and therefore fewer risks. The radical, disruptive things are associated with very great risks, do we actually understand everything? No lifetime data, we do not have anything, so how big is the chance that this does not end well? Much bigger, it is far less visible than an acceleration or improvement of a product."* – Managing Director Bo-flow (I3)

In other words, firms have to deal and assess the risk of radical innovations differently than of really new innovations. And really new innovations must be assessed differently for risk than incremental ones. More specifically, a higher risk is accepted earlier in radical new product ideas. The risk assessment that is made is much more uncertain in radical innovations (Product Manager Analyst Bo-flow, I5). Despite the uncertainty, the interviews pointed out that high-tech firms go much deeper into measuring the risk of radical innovations.

*"But I think that the risk is already higher in radical innovation by definition, so as you said, you see that we make slightly different decisions with those innovations. In incremental terms, we will be able to deviate somewhat faster, but radically we will deeply see how risks are and that involves different things: technology, development, potential, complexity, market, etc."* – Accountmanager PPA (I12)

This suggests the following proposition:

*Proposition 12c: The relationship between the use of risk as a decision criteria and effectiveness is influenced by the innovativeness of new product ideas*

To give an overview, the following conceptual model illustrates the moderating effect of the innovativeness of new product ideas. The moderating effect cannot be added in the previous conceptual model of the relationships (figure 9), because the relationships and the moderating effect were examined at the same time, and that means that it was not yet clear which relationships were discovered between the characteristics and the four goals of effectiveness.

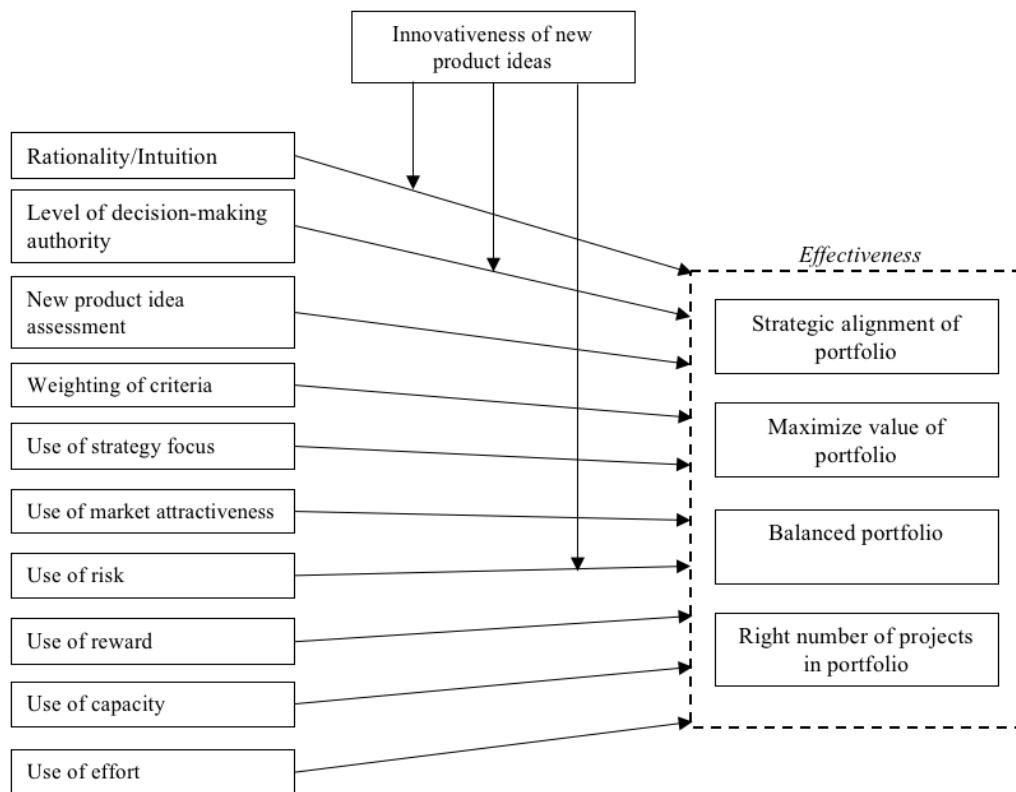


Figure 10: Conceptual model moderating effect

## 5. CONCLUSION

The main objective of this research was to improve the understanding of project selection methods to help guide managers in the high-tech industry to choose and create the most effective project selection method, and to what extent the difference between radical, really new and incremental innovations influences that process. More specifically, this research focused on discovering relationships between characteristics of project selection methods and the four goals of effectiveness in order to know which type of project selection method is effective when the innovativeness of new product ideas is taken into account.

The research question is:

*Which type of project portfolio selection method of an high-tech firm is effective when the innovativeness of new product ideas is taken into account?*

This research took place through a multiple case study wherein 13 informants from seven Dutch high-tech firms were interviewed, together with document reviews and a participant observation at one high-tech firm called Bo-flow. Project selection methods in seven high-tech firms are benchmarked to create understanding of the process of project selection.

Being able to conclude that each high-tech firm developed its own unique project selection method under their circumstances, it is impossible to pronounce which specific type for each high-tech is the most effective. It was realized during this research that a simple implemented project selection method can have huge benefits to firms. This method, including a procedure for the decision-making process and a tool/technique for assessing new product ideas, can be customized completely to the needs of a firm, using preferred parameters with appropriate weights to reflect the firm's strategy. In other words, there is no single method that fits all kinds of portfolios. However, a number of characteristics and aspects have been discovered that can increase the effectiveness for every high-tech firm.

First of all, high-tech firms strongly prefer a rational decision-making process, however, the results reveal that a fully rational decision-making process is impossible. It has even proved effective to use intuition as well, because intuition strengthens rational analyses and a rational approach also strengthens intuition. With rationality the predetermined strategic goals can be better pursued when decision-makers take these goals consciously in mind during the selection of projects. Therefore, it is important that high-tech firms clearly define and communicate their corporate and business strategy and link concrete goals to it. The intuition can then be the decisive factor based on past experiences and feelings of the decision-makers. It is also possible conversely, when intuition serves as an idea explorer, after which a rational collection of information underpins the idea in order to select it. Additionally, before the ultimate decision is made whether or not select a project, it is most effective to assess the new product idea interdependently with other new or existing projects. The results reveal that this has a positive influence on the balance between available resources and the number of projects in a portfolio, particularly by creating synergies or by using the same knowledge for multiple projects.

Furthermore, due to the fact that the innovativeness of new product ideas has an influence on some relationships between certain characteristics and effectiveness, it is most effective to separate the decision-making process of radical innovations from really new and incremental

innovations from the moment of the assessment. A reasoning for this is that the results pointed out that the level of decision-making authority is different for these types of new product ideas in an effective project selection method due to the difference in uncertainty and the amount of the investment. With radical new product ideas, the decision-making authority must be assigned to top managers, while in the case of incremental innovations the middle managers can be responsible. In really new innovations, a combination is possible, depending on the uncertainties it entails. These uncertainties also directly indicate a different moderating effect, namely the influence of innovativeness on the relationship between the use of risk and decision criteria and effectiveness. The decision-makers have to take a higher risk into account with radical innovations and also accept this earlier than with incremental ones. Regardless of the innovativeness of a new product idea, the interviews have shown that in an effective project selection method the decision-making authority must be assigned to a group of people with different disciplines. In the case of radical innovations, the group consists of top managers and in the case of incremental innovations middle managers. A group decision-makers will temper the political behaviour and stimulates the pursuit of the four goals of effectiveness.

Moreover, it has also been found that the most reliable way to anticipate the future is by understanding the firm's current state of affairs. This will lead to a more effective project selection method. Therefore, high-tech firms must map current issues and keep them up to date in order to make better choices.

And last but not least, the results reveal that high-tech firms make the most use of the following decision criteria; a strategy focus, an expected reward and the available capacity. However, these criteria depend on the firm's strategic goals. These goals can be translated into the weighting of decision criteria that new projects must meet in order to achieve some or all four goals of effectiveness, which the firm prefers. Creating and implementing a structured project selection method, which is clear for everyone inside a firm, where all new project follow a predetermined procedure, even if that process is different for radical product innovations than for really new and incremental product innovations, will contribute to the effectiveness of the method. The challenge is to choose strategic goals that would benefit the firm the most and include these goals into their project selection method.

## 6. DISCUSSION

This research provides a new perspective on project selection within PPM, in the context of Dutch high-tech firms. Furthermore, it points out that many more aspects are important to realize an effective portfolio, such as a clearly defined concrete strategy and good knowledge about the current state of affairs of a firm. However, more research is preferred to study the effectiveness of project selection methods in different ways and contexts.

### 6.1 Theoretical implications

The major contribution of this research is that understanding is created regarding the effectiveness of a project selection method whereby the innovativeness of new product ideas is taken into account. While most research in the field of project selection within PPM focuses largely on developing tools and methods (Archer & Ghasemzadeh, 1999; Cooper et al., 2001; Kaiser et al., 2015; Constantino et al., 2015), this study focused on the effectiveness of project selection. Over the past decades researchers have developed theories about how to organise PPM. Although different aspects have been elaborated during their studies, no complete model of aspects regarding effectiveness has emerged. Thus, the main contribution, concerning the purpose of identifying relationships with the four goals of effectiveness used in this research, is the development of the conceptual model. Additionally, characteristics of current tools and techniques of project selection from current literature are separated and emphasized in the relationships with effectiveness. These characteristics are divided into three areas; decision-making characteristics, scoring characteristics and content characteristics, but also other aspects have been discovered that influence the four goals of effectiveness. In this study, these relationships are deepened much more and are related to one or more of the four goals that a characteristic influences.

First of all, previous research (Kester et al., 2011; Dean & Sharfman, 1996) indicates that rationality, intuition and politics interact with each other and that every combination is possible. This was partly highlighted in this research, because the results reveal that rationality and intuition not only can interact with each other, but that there is always a combination of rationality and intuition in every decision-making situation regarding project selection and defining the firm's strategy. Political behavior is not connected to this, except that it appears that it mainly happens unconsciously, so intuitively; however, this behavior is more involved in the level of decision-making authority.

It was expected that each goal of effectiveness will be influenced by at least one of the content characteristics, which are the decision criteria for selecting a new project. However, the results did not completely reflect this expectation, because no criteria influences the goal balanced portfolio. This could be explained by the fact that the high-tech firms included in this study are more matured, as a result of which they have already achieved that balance in their portfolios. The researcher expects this to be different for high-tech start-up, but that will have to be examined in further research.

Furthermore, this research provides a contribution concerning the use of tools/techniques and methods in combination. This is an area which is rather unexplored. Previous studies focused

on developing tools/techniques and methods for PPM in isolation from each other. For example, Archer & Ghasemzadeh (1999) developed a method to simplify and organize the decision-making process of project selection and Cooper et al. (2001) developed some tools/techniques for the assessment of new product ideas beforehand. Concluding, previous research fails to provide this more detailed knowledge of the use of a combination, while this research combines tools/techniques and the decision-making process of project selection. Additionally, in contrast to the current literature, results of the interviews indicate that firms often do not use the tools/techniques for idea assessment which Cooper et al. (2001) describe in their research. Most high-tech firms developed their own unique project selection method under circumstances which are the most appropriate for their firm.

Another contribution of this research is that it discovered certain aspects that influence the four goals of effectiveness of Cooper et al. (2001). These aspects are the corporate and business strategy, and the knowledge about the current state of affairs of a firm. Earlier research have delineated the process of project selection so that strategic aspects are not mentioned, while the results reveal that the strategy was found to be a main influencing factor on the four goals of effectiveness. These influences can of course be explored more deeply in further research.

As mentioned above, the four goals of measuring a project selection method's effectiveness are not new for the PPM literature, but the diverse included aspects and characteristics are more detailed in the conceptual model than what is normally found in the literature. Therefore, the contribution from developing this model is the classification and specification of the aspects and characteristics important for creating an effective project selection method. However, this model is not a finale one including every relevant aspect and characteristic of an effective method, but it takes a step forward in the process of achieving a more complete understanding.

## **6.2 Limitations & recommendations for further research**

This research has the following limitations. First, time constraints limit the exhaustiveness of this multiple case study, as a result that only one informant per external case was interviewed, except for Ntech. This means that no within-case analysis for these cases were conducted, making the researcher must believe the answers of the particular informant. Therefore, it is recommended for further research to conduct an in-depth multiple case study with more interviews per case to find out if the findings of this research can be confirmed.

Second, due to low accessibility or high-tech start-ups, the included high-tech firms are relatively old in this research. As a result, no results were found about the differences between young and old firms, while the researcher expect this now. This expectation arose because informants often indicated that they are now pursuing goals and therefore using other decision criteria than in the start-up phase. Therefore, it is recommended to incorporate both start-up high-tech firms and older high-tech firms in future research.

Third, the questionnaire was designed in a way to prevent bias, by not specifically appointing certain relationships in advance, but asking the informants where certain characteristics lead to and what can lead to the goals of effectiveness in terms of project selection. As a result, not all

previously expected relationships have been discovered, but that does not mean that they are not there. Especially with decision-making characteristics it is not really clear which leads to the most effectiveness with regard to the four goals, but there are answers given about decision-making situations in general. For example, a challenge for future research is to study the decision-making authority more deeply. This research did not clearly show which approach, top-down and bottom-up, influences which of the four goals of effectiveness and which aspects are even more involved or decisive. It could be interesting and beneficial to use the knowledge that has been generated in this multiple case study to do a quantitative analysis of how project selection methods are applied in practice. Therefore, it is recommended to conduct in the future a quantitative research on a bigger scale to further explore the relationships between project selection methods and the four goals of effectiveness.

Fourth, because the relations between characteristics of project selection methods and the four goals of effectiveness have been investigated simultaneously with the moderating effect of the innovativeness of new product ideas, the moderating effects found do not relate to newly discovered relationships, but purely to the previously discovered characteristics with effectiveness in general.

Last, PPM consists of two different parts; (1) project portfolio selection and (2) the management of a portfolio (Patanakul et al., 2013). However, due to the time constraints, this research only focuses on the first part, while both parts actually influence each other because between project selections the portfolio must be managed. It would also be interesting to look closer into how project portfolio management is structured in the most efficient way in high-tech firms. Thus, it is recommended to investigate in further research PPM as a whole with regard to effectiveness.

### **6.3 Managerial implications**

This research holds several managerial implications for Dutch high-tech firms and specifically for Bo-flow.

#### ***6.3.1 For Dutch high-tech firms***

Each innovative high-tech firm could use the results of this research to improve their project selection method within PPM. However, each firm should first study their decision-making process to understand which the commonly used decision criteria the made decisions are based on. The development of an effective project selection method takes time and the best results are gotten with a continuous trial and error.

Project selection within PPM has gained an increasing interest with a strong focus on developing and using decision-making models and tools/techniques for new product idea assessment. However, this research has shown that creating an effective project selection method involves more considerations than just applying some models and tools/techniques. Different aspects and characteristics need to be taken into account at the same time as such models and tools/techniques are chosen.

The first aspect that high-tech firms have to deal with specifically is their strategy. It is necessary to link goals to their corporate strategy and to their business strategy that are clear to

everyone in the firm. Transparency and communication are of great importance for this. Herefore, recommendations are to define the strategy in a concrete way on paper whereby all employees can always access it. This ensures that there is no ambiguity about which way a firm wants to go and that everyone is focused on the strategic goals. So, in order to benefit as much as possible from the project selection method, it is clever to make an inventory of the requirements to fulfil.

Furthermore, when firms use the same base of resources for projects with a different degree of innovativeness, the conclusions in this research have shown that it can be feasible to separate the processes for radical projects. The main reason for this is that radical projects are assessed differently because of the high unpredictability and high risk. In addition, radical projects have a more expensive price tag which makes it a well-considered decision often taken by top managers. Regardless of whether the project selection process is separated or not, the results of this multiple case study reveal that if radical, really new and incremental projects are included in the same portfolio, the selection processes must allow taking into account different ways of assessing new product ideas, different strategies and different decision criteria.

Additionally, the results reveal that it is crucial to allow managers, both top managers and/or middle managers, with different disciplines to be involved in deciding which projects will be selected. For example, sales people know the market because they are often in contact with customers, while R&D people and product managers know more about the ins and outs of a technology. Therefore, it is recommended to bring this knowledge together by means of a group with people with different disciplines in order to make final decisions about selecting projects. Another important aspect which has been found in this research is an up to date knowledge about the current state of affairs of a firm. Especially for firms with a large product range that operate in different markets, it is difficult to map all current positions with regard to sales, turnover, capacity, lead time, planning, etc. However, if these states of affairs are kept up to date and accessible to managers, it makes it much easier to achieve a good balance between available resources and projects and to get more value out of the portfolio. High-tech firms could achieve this by purchasing and implementing a software package which keeps track of this.

### ***6.3.2 For Bo-flow***

The above recommendations are also useful for Bo-flow. However, because Bo-flow, compared to the other included high-tech firms, has been investigated more deeply, more specific managerial implications can be made. To begin, it has been shown that not all new projects are developed in the same way. One of the insights Bo-flow could gain from this research is to develop a project selection method in which all new project applications arrive at the same point and start in a kind of state-gate process model. Project proposals are currently not formally documented, but with the implementation of a stage-gate process, ideas could be brought into this process early. A good example for this is Archer & Ghasemzadeh's framework (1999). This would make it easier to coordinate and work with new product ideas. Also, everyone can bring a new idea to the table, as long as it goes through the same process. And then, after the first stage, both radical product ideas and really new or incremental product ideas should follow their own selection process. In addition, the sales people should be early

involved in the process of radical new product ideas, so that they become more enthusiastic to sell it eventually.

To go deeper into the distinction between the innovativeness of new product ideas, it is recommended that Bo-flow establishes a balance between radical, really new and incremental innovation based on percentages of their resources. Some other high-tech firms already use such a balance, which includes the following resource allocation; 70% for incremental innovations, 20% for really new innovations and 10% for radical innovations. In this way the innovation aspect of the firm remains intact.

Furthermore, the results reveal that there is still disagreement about the weighting of decision criteria. This has to do with the broad and unclearly defined corporate and business strategy. It is not clear enough for employees which strategic goals Bo-flow wants to pursue and which decision criteria apply to it. Thus, the recommendation is to first get a good picture of the strategy a firm wants to pursue and which goals can be linked to this. These goals can then be more easily converted into criteria that new projects must meet.

Additionally, Bo-flow is a firm that finds it difficult to reject new projects. Bo-flow has grown because of their wide product range and the possibilities they offer for specific customer solutions. This has created a broad and well-filled portfolio, but there are also still many projects under development that do not actually have enough capacity available. In addition, employees work on different projects that each require a different technology and/or knowledge. Acquiring knowledge about the current state of affairs is therefore mainly for Bo-flow of high importance. Before a project selection method can really work, they first have to look at all projects that are still under development. Perhaps some can be deleted if the strategy is defined more concretely. And then first the projects that have already been selected have to be developed. When the capacity permits it, then there is the possibility to select a new project. The Kanban method that Nolsearch uses is a suitable solution for this. Thus, Bo-flow should continue the process of limiting the number of projects that individuals are working on at the same time and possibly think about putting more constraints on the total number of projects in development in each product group. If they can reduce the number of projects in development, Bo-flow will have less movement of resources, the income from projects will come earlier and that with less risk, because the current risk of project delays due to a lack of overview and capacity can result in loss of customer and market opportunities.

The final recommendation concerns the assessment of new product ideas. Because Bo-flow has not followed a specific method for selecting projects in recent years, little documentation has been stored for selecting new projects. From now on they should make this commitment strictly, which mainly includes the pre- and post-calculation of each new project. This information is useful for all future project proposals to realize a small gap between pre- and post-calculations. Because of this, the forecasts will be getting better, the related risks will be reduced and the market can be identified better.

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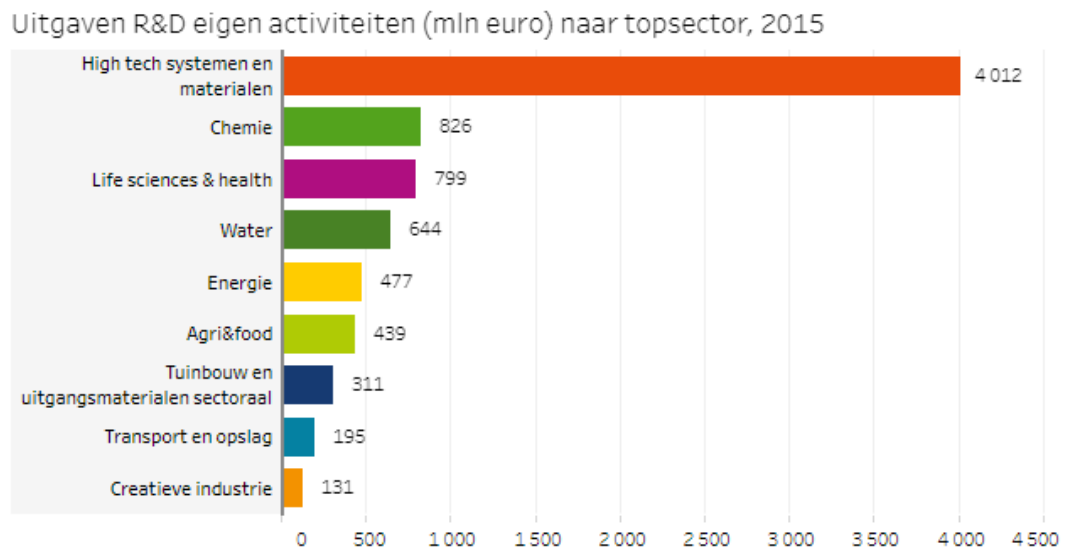
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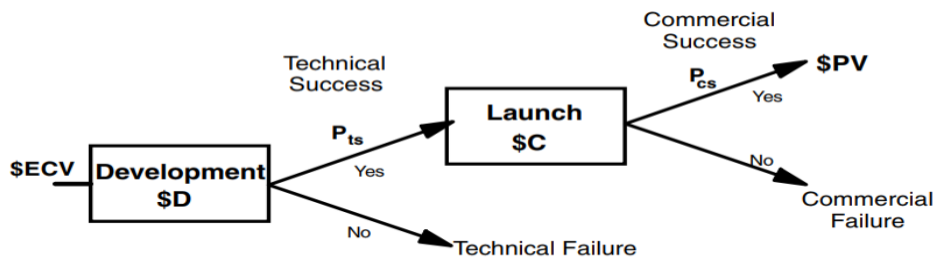
## Appendix 1: Figure about R&D expenses



CBS (2017): Monitor top sectors, R&D expenses

## Appendix 2: Project selection tools/techniques

### A. ECV approach (Cooper et al., 2001)



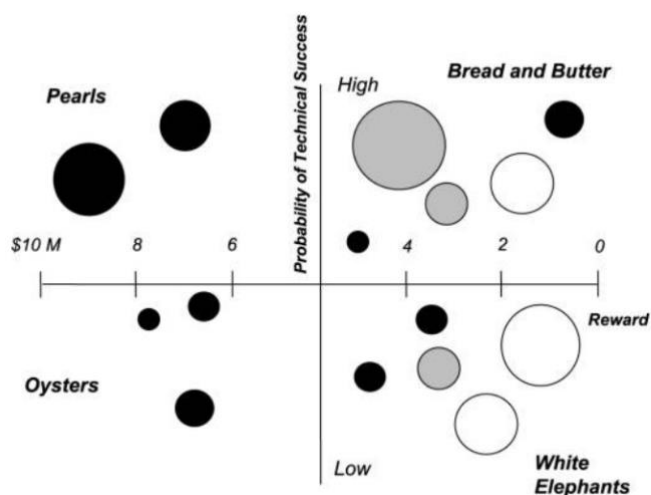
$$ECV = [(NPV * P_{cs} - C) * P_{ts} - D]$$

$\$ECV$  = Expected Commercial Value of the project  
 $\$PV$  = Income stream from project (discounted to present)  
 $\$C$  = Commercialization costs (capital equipment & market launch)  
 $\$D$  = Development costs  
 $P_{ts}$  = Probability of technical success  
 $P_{cs}$  = Probability of commercial success (given technical success)

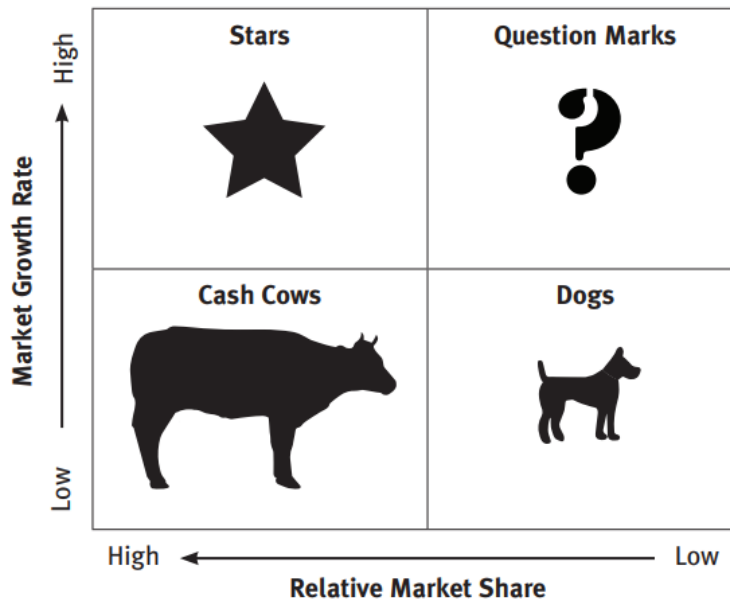
### B. Strategic buckets approach (Cooper et al., 2001)

Bucket #1: New Products for Product Line A Target Spend: \$8.7M	Bucket #2: New Products for Product Line B Target Spend: \$18.5M	Bucket #3: Maintenance of Business for Product Lines A & B Target Spend: \$10.8M	Bucket #4: Cost Reductions for All Product Lines Target Spend: \$7.8M
Project A 4.1	Project B 2.2	Project E 1.2	Project I 1.9
Project C 2.1	Project D 4.5	Project G 0.8	Project M 2.4
Project F 1.7	Project K 2.3	Project H 0.7	Project N 0.7
Project L 0.5	Project T 3.7	Project J 1.5	Project P 1.4
Project X 1.7	<b>Gap = 5.8</b>	Project Q 4.8	Project S 1.6
Project Y 2.9		Project R 1.5	Project U 1.0
Project Z 4.5		Project V 2.5	Project AA 1.2
Project BB 2.6		Project W 2.1	

### C. Bubble diagram (Cooper et al., 2001)



### D. BCG matrix (Campbell et al., 2014)



### E. Scoring model (Cooper et al., 2001)

#### 1. Reward:

- Absolute contribution to profitability (5 year cash flow: cumulative cash flows less all cash costs, before interest & taxes).
- Technological payback: the number of years for the cumulative cash flow to equal all cash costs expended prior to the start-up date.
- Time to commercial start-up (years).

#### 2. Business Strategy Fit:

- Congruence: how well the program fits with the strategy (stated or implied) for the product line, Business and/or Company
- Impact: the financial and strategic impact of the program on the product line, Business and/or Company (scored from "minimal" to "critical").

#### 3. Strategic Leverage:

- Proprietary position (scored from "easily copied" to "well protected via patents, trade secrets, etc.).
- Platform for growth (scored from "one of a kind" to "opens up new technical & commercial fields").
- Durability: the life of the product in the marketplace (years).
- Synergy with other operations/businesses within the corporation.

#### 4. Probability of Commercial Success:

- Existence of a market need.
- Market maturity (scored from "declining" to "rapid growth").
- Competitive intensity: how tough or intense the competition is.
- Existence of commercial applications development skills (scored from "new" to "already in place").
- Commercial assumptions (from "low probability" to "highly predictable").
- Regulatory/social/political impact (scored from "negative" to "positive").

#### 5. Probability of Technical Success:

- Technical gap (scored from "large gap" to "incremental improvement").
- Program complexity (scored from "many hurdles" to "straightforward").
- Existence of technological skill base (scored from "new to us" to "widely practiced in company").
- Availability of people & facilities (scored from "must hire/build" to "immediately available").

These 19 rating questions are each scored 1-10. Each question is anchored (what a 10 is, what a 1 is). Questions are added in a weighted fashion to yield the five Factors. The five Factors are added, also in a weighted fashion, to yield the Program Attractiveness Score, which is used to make Go/Kill and prioritization decisions. See also . See also Cooper et al., 1997a and 1998a.

### Appendix 3: Overview informants

Informant	Firm	Job function	Interview	Date	Time duration
Informant 1	Bo-flow	Project Leader R&D	Pilot	11-05-2018	53 minutes
Informant 2	Bo-flow	Manager Marketing & Sales	Pilot	25-05-2018	79 minutes
Informant 3	Bo-flow	Managing Director	Part I-II-III	05-06-2018	77 minutes
Informant 4	Bo-flow	Manager R&D	Part I-II-III	11-06-2018	92 minutes
Informant 5	Bo-flow	Product Manager Analyst	Part I-II-III	20-06-2018	85 minutes
Informant 6	Bo-flow	Product Manager	Part I-II-III	04-07-2018	75 minutes
Informant 7	Ntechno	Business Developer	Part I-II-III	05-06-2018	55 minutes
Informant 8	Ntechno	Project Manager	Part I-II-III	11-06-2018	67 minutes
Informant 9	Prowater	Manager Product Marketing	Part I-II-III	06-06-2018	61 minutes
Informant 10	Nolsearch	Product Manager	Part I-II-III	07-06-2018	64 minutes
Informant 11	Veprecise	R&D Manager	Part I-II-III	12-06-2018	75 minutes
Informant 12	PPA	Accountmanager	Part I-II-III	18-06-2018	78 minutes
Informant 13	Spe-metal	R&D Manager	Part I-II-III	26-06-2018	79 minutes

## Appendix 4: Question list interviews

### **Introduction by the interviewer**

*This research is conducted for writing my Master Thesis at the Radboud University in Nijmegen during the master Business Administration – Innovation and Entrepreneurship. The main focus of my research is on project portfolio selection, which is according to many researchers a fast developing area about an important decision-making process in innovation management.*

*I do research into the effectiveness of selecting the right innovation projects within a firm's product portfolio. This research aims to improve the understanding of project selection methods to help guide managers in the high-tech industry how to choose and create the most effective project selection method, and to what extent the difference between radical, really new and incremental innovation projects influences that process. For measuring the effectiveness of project selection methods, I use the four goals drawn up by Cooper: (1) maximize value of the portfolio, (2) achieving a balanced portfolio, (3) make sure that the portfolio is aligned with strategy and (4) pick the right number of projects.*

### **Informant's role and responsibilities within the firm**

1. Who are you and what is your background?
2. What is your job function and position within firm X?
3. How many space do you have to make your own decisions?
4. What is your role within firm X in relation to project portfolio management?

## **PART I - Current project selection method**

### **Decision-making**

5. Can you describe how projects are selected in your firm? And how do you think about your methodology?
  - If it is not clear: can you describe the process from an idea to project development with an example?
6. Who have the decision-making authority to select projects and how do you think about that? And who else are involved in this project selection decision-making process?
7. Do you have any decision support system or procedure for selecting projects? If yes, how does it works?

### **Tools/techniques**

8. What kind(s) of tool(s)/technique(s) are being used within your firm for assessing new product ideas? And why does your firm use these?
9. On the basis of which scoring criteria are projects assessed and compared with each other in order to select the right projects? And why?
10. Which scoring criteria do you think are very important? Do you make a trade-off between criteria? Why and how? Which one weights the most and why so?
11. Do you assess projects independently or interdependently? How and why?

### **Innovativeness of new product ideas**

12. Are innovation projects in your firm distinguished in the degree of innovativeness? If so, how?  
*Try to understand how the distinction matches with that of Garcia & Calantone.*

- If yes, are radical projects, really new projects and incremental projects selected in a different way (for example based on different criteria)? Can you give an example?
- If no, how do you think about this distinction? And do you think that when firms have these different innovative projects, do they have to select these projects differently? And how should that be?

## **PART II - The goals of effectiveness**

### Strategic alignment

1. Could you describe the business strategy of your firm? Is that clear to you?
2. Do the decision-makers consciously keep the business strategy in mind when making decisions? Or is it just based on feelings? Can you explain that?
3. Do you use strategic alignment as a predetermined goal when selecting projects? If so, how? And why?
4. What influences the extent to which projects are assessed for their strategic fit?
  - Why are your projects assessed on a fit with the strategy or why not?
5. Do you think your firm's portfolio fits with the firm's strategy? Why yes or why no? And how does that turn out?

### Maximize portfolio value

6. Do you have selected projects in previous years based on an high expected financial value?
7. Was that an important criteria and a predetermined goal for selecting projects?
8. Was the expected return consciously taken into account as a substantiation/argument for selecting a project during the assessment of a project? Or how do you deal with that?
9. What influences the extent to which projects are assessed for their expected value to achieve a maximum portfolio value?
  - Why are your projects selected based on an high expected value or why not?
10. What do you think leads to a maximum portfolio value? In other words, how can firms strive for or realize a maximum portfolio value?
11. Do you think your firm's project portfolio has reached a maximum value or that it can be much higher?

### Portfolio balance

12. How are projects in the portfolio spread in terms of long-term/short-term, high risk/low risk and different markets?
13. Do you try to spread the overall risk over different projects? If so, how? If no, why not?
14. Do the decision-makers consciously keep the overall risk into account when selecting projects? Can you explain that?
15. Do you use portfolio balance as a goal when selecting projects? If so, how?
16. What influences the extent to which the firm's overall risk is spread over a mixed combination of projects?
  - Why do you spread the firm's overall risk over different projects or why not?
17. Do you think your firm's project portfolio is in balance, in words of spreading the firm's overall risk? And why do you think that?

### Right number of projects

18. Do you have often problems with a lack of resources? Or a lack of a specific type of resources? If so, how do you solve that?

19. What influences the extent to which a firm does or does not have enough resources for the projects in the portfolio?
20. Do you think that you can predict this consideration, between projects and resources, well, when selecting projects? If so, how do you do that and why?
21. Do you think your firm has the right number of projects currently in development based on the available resources? Why do you think yes or why do you think no?

### **PART III - The characteristics and the innovativeness of new product ideas as moderating effect**

#### Rational/political/intuition (decision-making)

1. What impact can a rational decision-making process, a targeted approach based on researched information and substantiation, have on project selection?
2. What impact can an intuitive decision-making process, a not-targeted approach based on past experiences and feelings, have on project selection?
3. What impact can a political decision-making process, an approach based on own interests and power, have on project selection?
  - And when do you think political decision-making is conscious or unconscious? Can you explain that with an example?
4. If you take the three levels of innovativeness in your mind, how do you think about the impact they have on the relation between the decision-making process (*rational/political/intuition*) of project selection and the goals of effectiveness?

#### Top-down/bottom-up (decision-making)

5. What impact can the level of decision-making authority, product managers or managing board, have on the decision-making process of project selection? How do you think about that?
6. What do you think product managers can do better in selecting projects than top managers, and/or vice versa?
7. If you take the three levels of innovativeness in your mind, how do you think about the impact they have on the relation between the decision-making process (*top-down/bottom-up*) of project selection and the goals of effectiveness?

#### Independent/interdependent (scoring)

8. What impact can the way of assessing new product ideas, independently or interdependently, have on project selection?
9. If you take the three levels of innovativeness in your mind, how do you think about the impact they have on the relation between this scoring characteristic (*independent/interdependent*) of project selection and the goals of effectiveness?

#### Weighting of criteria / all equally important (scoring)

10. What impact can the way of weighting projects, yes or no, have on project selection?
11. If you take the three levels of innovativeness in your mind, how do you think about the impact they have on the relation between this scoring characteristic (*weighting criteria/all equally important*) of project selection and the goals of effectiveness?

#### Strategy focus (content)

12. Where does a strategic focus lead to in selecting projects? And why?

13. If you take the three levels of innovativeness in your mind, how do you think about the impact they have on the relation between strategy focus as a criteria of project selection and the goals of effectiveness?

Market attractiveness (content)

14. Where does the use of market attractiveness as a criteria lead to, in terms of project selection? And why?
15. If you take the three levels of innovativeness in your mind, how do you think about the impact they have on the relation between market attractiveness as a criteria of project selection and the goals of effectiveness?

Risk (content)

16. Where does the use of risk as a criteria lead to, in terms of project selection? And why?
17. If you take the three levels of innovativeness in your mind, how do you think about the impact they have on the relation between risk as a criteria of project selection and the goals of effectiveness?

Reward (content)

18. Where does the use of reward as a criteria lead to, in terms of project selection? Why?
19. If you take the three levels of innovativeness in your mind, how do you think about the impact they have on the relation between reward as a criteria of project selection and the goals of effectiveness?

New characteristic

*When the informant has appointed a certain new characteristic in the previous part, ask the following question.*

- *If you take the three levels of innovativeness in your mind, how do you think about the impact they have on the relation between [the new characteristic] of project selection and the goals of effectiveness?*

