

Past research has identified that innovation portfolio management is about efficiently managing the right innovation portfolio projects. However, the relevant literature has fairly unobserved decision processes which help to maximize the value of the entire innovation portfolio.

This work analyzed decision procedures within the context of innovation portfolio management; especially, the project go/stop-decision processes. Founded on a theoretical basis two decision making experiments were developed and a distinct set of hypotheses by two large-scale experimental studies were tested.

The present work is aimed at making a valuable contribution to conceptual research about decision making in the context of innovation portfolio management, and the experimental based research field. The results of these studies help to get a detailed understanding of the decision making processes and may lead to a better understanding of project management within an innovation portfolio by firms and by decision makers in general.

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Behrens

Decision Making in Innovation Portfolio Management

Judith Behrens

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An Experimental Paper Series

**DECISION MAKING
IN INNOVATION PORTFOLIO MANAGEMENT**

- AN EXPERIMENTAL PAPER SERIES -

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to obtain the academic title
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-An experimental paper series-

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FOR MY PARENTS

Foreword

Innovation portfolio management (IPM) refers to the assessment, selection and prioritization of multiple innovation projects with the objective to focus scarce firm resources on the strategically and financially most promising innovation projects. An important element of IPM is the stopping of failing projects at gates along the innovation process. Without the termination of failing innovation projects, the objectives of IPM cannot be achieved.

Effective IPM has become a critical success factor of innovations. At the same time, it has not received much attention in the scientific literature so far. In particular, existing research has only begun to understand the drivers of managers' portfolio decisions. Understanding decision making processes is an important key for achieving better IPM in firms. The dissertation of Mrs. Behrens is therefore an important contribution to close the existing research gaps with regard to the following main questions: (1) How do certain characteristics of innovation projects impact portfolio decisions? (2) How does the portfolio context matter when managers assess the attractiveness of a single innovation project? (3) How do personal characteristics of the decision maker impact portfolio decisions? (4) What can help to avoid escalation of commitment, i.e. that managers hold on to failing innovation projects?

To answer these questions, Mrs. Behrens has for the first time collected a meaningful sample from managers that had been making innovation portfolio decisions in their companies for many years. This increases the external validity of results. She uses multiple methods such as experiments, conjoint analyses and surveys to collect the data from senior managers. This yields very detailed insights into managers' portfolio decisions. Mrs. Behrens makes a host of very interesting findings. One interesting result is that a manager's hierarchical position and his/her experience impacts portfolio decisions. Also, portfolio-fit considerations play an important role for the assessment of single projects. The data further shows that stopping a failing innovation project is a very difficult managerial task, especially once the product has been launched on the market. Strategies to reduce this escalation of commitment to a failing

project include the advice of a person without strong prior beliefs about the respective project (consultant) and the use of visualization tools such as portfolio graphs and scorecards.

Overall, the dissertation of Mrs. Behrens helps academics and managers to better understand some fundamentals of better innovation portfolio decisions. It is interesting for academics because the dissertation develops and tests a comprehensive theoretical framework that identifies critical aspects of innovation portfolio decisions. Since only part of that could be analyzed by Mrs. Behrens, her dissertation offers multiple ideas for further research in this area. The dissertation is also important for managers because it offers concrete and hands-on advice for managers to improve innovation portfolio decisions. This should have a positive effect on innovation performance. I therefore highly recommend this dissertation to both, academics and managers.

Vallendar, July 2011

Prof. Dr. Holger Ernst

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The role of decision making processes in innovation management has a huge impact on firm performance and has been identified as a challenging research field in academic research. This dissertation continues two large-scale experimental studies that provide you with useful recommendations on how to improve decision making processes within a firm. For researcher, my studies results encourage future experimental studies in this field.

Several persons helped me on my research journey. Academically, I would like to thank my supervisor, Prof. Dr. Holger Ernst (Chair of Technology and Innovation Management, WHU) for his support, advice and our discussions which encouraged and challenged me throughout the dissertation project. During my three years as research assistant at his chair, he provided the freedom to do research with an international perspective. I would also like to thank my co-advisor Prof. Dr. Dietmar Grichnik (Chair of Entrepreneurship and Technology Management, St. Gallen) for co-reviewing this dissertation.

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Judith Behrens

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“Nothing is more difficult, and therefore more precious, than to be able to decide.”

(Napoleon Bonaparte)

"Thinking is easy, acting is difficult, and to put one's thoughts into action is the most difficult thing in the world." (Johann W. von Goethe)

Chapter A: Introduction to the experimental paper series

1. Relevance of the subject

Decision making in the context of innovation portfolio management is a critical task of innovation management. It affects a firm’s sensing, seizing, and transforming of innovation opportunities, and therefore influences the success of a firm and the survival in general (Teece, 2007; Cooper, Edgett, & Kleinschmidt, 1999). The issue of innovation portfolio management is not a new area. Prior research focused on portfolio management (Walsh, 2001; Szwajczewski & Mitchell, 2006), Research and development (R&D) portfolio value (Kolisch, Meyer, & Mohr, 2005; Linton, Walsh, & Morabito, 2002), R&D resource allocation and project prioritization (Brenner, 1994; Graves, Ringuest, & Case, 2000) and technology portfolio management (Jolly, 2003). Especially, innovation project decisions have been addressed in a variety of studies (e.g., Boulding, Morgan, & Staelin, 1997; Biyalogorsky, Boulding, & Staelin, 2006; Schmidt & Calantone, 2002). These studies underlined that innovation project decisions are one of the most difficult judgments to make in practice (Balachandra, Brockhoff, & Pearson, 1996; Cooper *et al.*, 1999) as firms face the critical decision in which markets, technologies, and products they should invest (Ernst, 1998).

Innovation portfolio management refers to the management of innovation projects at the project level and at the firm level. It involves finding a balance between a firm’s number of ongoing innovation projects, and available resources, skills, and capabilities (Cooper *et al.*, 1999). To capture value from innovation by successfully managing innovation projects, firms have to pay attention to two central issues: “doing innovation projects right” and “doing the

right innovation projects” (Cooper *et al.*, 1999). While most prior research into success aspects of new product development has focused on the first issue, innovation portfolio management concentrates on the second topic: “*doing the right innovation projects*” (Cooper, Edgett, & Kleinschmidt, 2002; Ernst, 2002). Developing the right projects is important to firm success and is often cited as a key competitive measurement (Chao & Kavadias, 2008).

An active and continuous management of a firm’s innovation project portfolio goes far beyond picking innovation projects (Coulon, Ernst, Lichtenthaler, & Vollmoeller, 2009). The entire mix of projects has to be taken into consideration and includes therefore a complex project go/kill-decision process (Cooper *et al.*, 2002). Decision making in the context of innovation portfolio management focuses on selecting and actively managing the right projects for a firm’s portfolio of innovation projects and links various key decision areas. Among them are project selection and prioritization, the resource allocation process across projects, and the implementation of the business strategy (Cooper *et al.*, 1999). Throughout the innovation portfolio management process, new projects need to be evaluated, selected and prioritized, whereas existing projects have to be rushed, killed, or de-prioritized (Cooper *et al.*, 2002). Managing multiple innovation projects across an innovation portfolio is a complex manner (Barczak, Griffin, & Kahn, 2009). The decision maker must consider all alternative portfolios options individually and compare project alternatives consistently. For example, if a firm has just ten innovation projects, there are more than thousand alternative possible portfolio constructions (Chien, 2002).

In the innovation project decision making process decision makers discover *two central decision making* errors. One type takes place when managers ignore that an innovation project will succeed and should be part of the overall innovation portfolio of the firm. Managers fail in going an appropriate *project go-decision*. There are many reasons for this sort of mistake, including the tendency of managers to seek only with innovation projects that fit our beliefs (Biyalogorsky *et al.*, 2006; Boulding *et al.*, 1997) or our experience background

(Kalra & Soberman, 2008; Agor, 1986; Giunipero, Dawley, & Anthony, 1999). The other fault occurs when decision makers do not *stop an innovation project* for lack of evidence that it could be a failure in the market. Such mistakes can occur of personal biases, wrong information and/or the escalation of commitment phenomenon; that is, “good money chasing bad” (Schmidt & Calantone, 2002). Escalation of commitment is the tendency of decision makers to persist with an innovation project in spite of negative feedback that the initial investment has not reached its goals. Projects like X32 (drug for treating psychosis) that survived despite multiple red flags are the outcome; some of them arrived at the market just to fail amazingly after introduction (Bonabeau, Bodick, & Armstrong, 2008).

Following this argumentation, which approaches and procedures can help to improve the decision making process and decision making behavior in innovation project selection? Which project attributes have an impact while managers make a project go/stop-decision? How can we use that information to improve the overall innovation portfolio? Successful companies across industries have recognized the importance of a professional innovation portfolio management decision process, and they have put emphasis on it in their strategy and innovation activities. For instance, the CEO of Atari North America lately explained in an interview “We are very focused on how we continue to grow as a best practice company, how we take a look at the portfolio of our products we have and how we maximize that portfolio” (Brightman, 2008). Once the firm has identified the appropriate strategy, a professional decision making process in innovation portfolio management enables to quantify and evaluate the best innovation projects for the portfolio.

Research on the specific improvement on the decision making process is still limited. The project selection literature has primarily focused on a rational perspective in the decision process. These methods focus on financial and mathematical optimization methods (Cooper, Edgett, & Kleinschmidt, 2001; Dickinson, Thornton, & Graves, 2001). However, recent research underlines that just focusing on financial issues in the decision making process

brings an unprofitable and unbalanced portfolio (Cooper *et al.*, 1999; Libertore, 1987). Especially, benchmarking studies conducted by Cooper et al. confirm that firms just looking on financial issues in the portfolio management system have performed worst (Cooper, Edgett, & Kleinschmidt, 2004a, b, c).

In addition, the project stop-decisions are critical decisions as these terminate projects which are not profitable for the overall portfolio. This termination decisions free project resources which hopefully generate better prospects for firm success. Nevertheless, managers often see a project termination decision as a personal failure as they already invested money and time into the development process (Boulding *et al.*, 1997; Schmidt & Calantone, 2002). Managers become committed to their past project decisions and it is therefore not easy for them to stop the innovation project. The escalation of commitment phenomenon is usually observed when managers are personally involved (Biyalogorsky *et al.*, 2006). Analyzing approaches for reducing the escalation of commitment phenomenon is an essential research topic as Schmidt and Calantone (2002) remind us that the escalation of commitment phenomenon is still under researched. Furthermore, Biyalogorsky et al. (2006) and Boulding et al. (1997) state that there is a clear need for further research to better understand when and how “to pull the plug”. Furthermore, the extant research on innovation portfolio managing decisions has offered little consideration in how as well as why specific go/stop- decisions are made, and how an optimized and effective decision making processes can be obtained.

2. Research questions and structure of dissertation

The outlined voids represent major research gaps because the decision making process within an innovation portfolio has major impacts on firm performance. In light of this fact, some authors have called for more research in this domain. With respect to the current research deficit of innovation portfolio management, it is necessary to structure and to analyze the decision making behavior in detail. Therefore, it is the aim of this dissertation to explore and improve the go/stop-decision process against the background of an efficient innovation portfolio management. It further evaluates specific characteristics and influence factors in the decision making process. In particular, on the basis of a literature analysis, this dissertation conducted two decision making experiments. These studies address, by way of example, the following research questions:

- What are decision making processes in the context of innovation portfolio management?
- How can these decision making processes and the decision behavior be categorized and at the end optimized?
- Which innovation project attributes have the strongest impact on the innovation portfolio management decision?
- Which approach helps decision makers to avoid funding the wrong innovation projects? Especially, how can decision makers relieve themselves from the escalation of commitment trap while stopping an innovation project?
- Are there disparities in the “espoused” decision making process (that is manager’s self reported data) and the “in use” (that is the innovation attributes which a manager considers while he or she is doing a project decision) while managers make innovation project decisions?

The dissertation is divided into five chapters. Figure 1 provides an overview on the structure of the dissertation.

Chapter	Title	General Content	Specific Content
A	Introduction to the paper series	- Relevance of the subject	
		- Research questions	
		- Structure of dissertation	
		- The topic innovation portfolio management	
B	Deciding to exploit: the project, the portfolio, and the person	- Analyzing the project exploitation process	- Project and strategic considerations in decision making
		- Innovation portfolio management decisions	- Managerial level and experience
		- Influence factors in the decision making process	- Experimental conjoint study with 126 R&D managers
			- Hierarchical linear modeling
C	What keeps managers away from a losing course of action? “Go-/stop- decisions” in new product development	- Optimizing innovation project management	- The influence of a consultant and visual decision aids
		- Approaches for reducing escalation of commitment	- Stage gate process
		- Go/stop-decisions in new product development	- Experiment with 137 R&D managers
D	Disparities in innovation portfolio management decisions – An experimental analysis of R&D managers’ introspection	- Impacts on the decision process	- Potential biases and disparities in decision making
		- Comparison in use and self-reported data	- Experimental conjoint study with 126 R&D managers
E	Summary and conclusion	Key findings	
		Academic and managerial implications	
		Limitation and outlook	

Figure 1: Structure of the dissertation

Chapter A serves as an introduction to the topic of decision making in the context of innovation portfolio management and points out the relevance of the subject in research and practice. In addition, the objectives of the dissertation are shown.

Chapter B analyzes how decision makers choose which innovation projects are to be exploited and which are not. Building on the product innovation, portfolio strategy, and managerial psychology literatures, I examine the inter-related attributes of the product, the portfolio, and the person. I use a conjoint field experiment to collect data on 4032 decisions

made by 126 R&D managers to test how project attributes and characteristics of decision makers influence the innovation portfolio.

In *chapter C*, I conduct a 4x2 experiment which analyzes whether specific approaches (the advice of a consultant and/or visual decision aids) can reduce escalation of commitment. This study focuses on the decision process while 137 R&D managers must decide whether to abandon the previously chosen course of action or to continue in the face of possible and increasing losses. Furthermore, I analyze time effects on the decision making process in a stage gate system.

In *chapter D*, I analyze potential biases and disparities in decision making processes. Especially, the disparities in self reported data and the “in use” decision processes are evaluated. Suggestions for improvement for decision making in the context of innovation portfolio management are discussed.

Finally, *chapter E* discusses the empirical findings. Key results and success factors of decision making in the context of innovation portfolio management are being summarized. Managerial and academic implications are outlined. Furthermore, shortcomings of the presented studies are pointed out and an outlook is drawn.

To sum up, the following issues emerge as the main goals of the present dissertation:

- Developing two experimental studies in the context of innovation portfolio management throwing on the product innovation, portfolio strategy and decision making literature in psychology and marketing.
- Identifying and examining influence factors while doing a project exploitation decision using an experimental conjoint analyses analyzed by hierarchical linear modeling (HLM).
- Proposing conceptual approaches for reducing the escalation of commitment phenomenon.

- Analyzing and discussing potential disparities, biases and errors in the decision making process.
- This dissertation has major contributions. It offers essential insights about decision makers by actively addressing the decision making process in the innovation portfolio management context.

Thus, the experimental paper series will help to diminish existing research gaps at the theoretical and at the empirical level. The present dissertation is aimed at making a valuable contribution to conceptual research about decision making in the context of innovation portfolio management, and the experimental based research field. The results of these studies will help to get a detailed understanding of the decision making processes. Apart from contributing to the literature and stimulating further academic work, the results of the study may be directly applied in practice in order to help firms cope with the difficulties and challenges experienced by innovation portfolio management. In addition, the present studies consist of an economic dimension by presenting results that may lead to a better understanding of project management within an innovation portfolio by firms and by decision makers in general.

3. Innovation portfolio management

3.1. Definition and aims of innovation portfolio management

Innovation portfolio management is critical to allocating firm's innovation resources efficiently (Cooper *et al.*, 1999). This involves go/stop-decisions with respect to individual projects in light of a firm's innovation strategy. Innovation portfolio management means that the wrong projects are stopped and the "right" projects are exploited (Cooper *et al.*, 2002). The decision is not based on independent criteria and facts; therefore, it is not a standardized process. Innovation portfolio management is about efficiently and timely reaching the right

innovation portfolio decisions, which include go/stop-decisions about innovation projects to maximize the value of the entire portfolio (Cooper *et al.*, 1999). Figure 2 visualizes the go/stop-decision process in the context of innovation portfolio management.

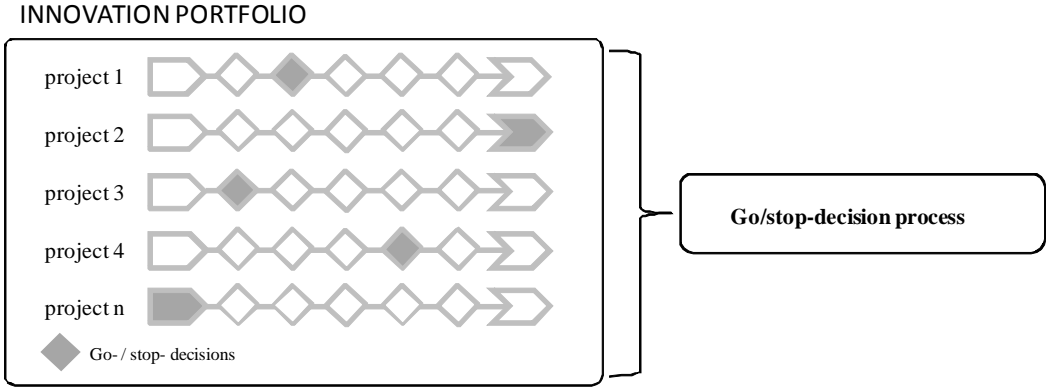


Figure 2: The decision making process in the context of innovation portfolio management

Seeing these key characteristics of innovation portfolio management, innovation portfolio management is defined based on prior work as follows (Cooper *et al.*, 2001; Griffin & Page, 1993; Graves *et al.*, 2000; Roussel, Saad, & Erickson, 1991):

Innovation portfolio management is a dynamic decision process, whereby a firm’s list of active new product projects is constantly updated and revised. Throughout this process, new projects are evaluated, selected, and prioritized. Existing projects may be accelerated, stopped, or de-prioritized, and resources are allocated and reallocated to active projects (Cooper et al., 1999).

Innovation portfolio management’s prior research suggests four major goals that firms attempt to achieve in their innovation portfolio management activities (Cooper *et al.*, 1999):

- 1) The overall purpose of innovation portfolio management is financial innovation success based on an increasing number of profitable new product or service launches.

Accordingly, the financial value of the company's innovation portfolio is wanted to be maximized. Without proficient innovation portfolio management, firms are at risk to have too many projects of relatively limited worth as there may be too many projects for the resources available.

2) Firms must find the right balance of their innovation portfolios. Companies often define project types according to different characteristics to monitor the balance of their projects and to define target percentages of particular project types.

3) Innovation portfolio management is designed to focus on core business areas to avoid new product effort that does not support the company's strategy. Specifically, innovation projects and their corresponding budgets need to be aligned with business unit strategy.

4) Finally, companies command a given set of resources, which need to fit the number of active innovation projects (Cooper et al., 2001; Cooper et al., 1999).

These four goals are affected by the decision making process within the firm. Though, work by Cooper et al. (2002) indicated that only 21.2 % of firms report having a well-executed portfolio management and that many firms rate their portfolio management as very weak in terms of the process to which it is put in place.

3.2. Decision making in innovation portfolio management

The decision making process in innovation portfolio management is characterized by uncertain and unstable information, dynamic opportunities, multiple goals, several strategic considerations, interdependence among projects, and multiple decision-makers and locations (Cooper *et al.*, 2001; Frishammar & Hörte, 2005). As a result, innovation portfolio management principally refers to a decision-making framework. Innovation projects are assessed, and this focuses the innovation portfolio based on go/stop-decisions at key milestones. Innovation portfolio management helps to prioritize and reallocate resources. Also, innovation portfolio management involves the value maximization and balance within the portfolio. Therefore, I do not consider innovation portfolio management as an isolated process. Instead, it refers to a variety of interrelated decisions and activities over time to refine and implement the organization's innovation strategy by allocating available resources. Therefore, firm's need to implement a go/stop-decision process which focuses on the interrelated goals of innovation portfolio management to maximize firm performance (Balachandra, 1984) as the outcome and performance of the innovation portfolio is clearly linked to the outcome of the decisions in the innovation portfolio management process.

To analyze decision making processes, experiments are a well known and prevalent research method (e.g., Schmidt & Calantone, 2002; Boulding *et al.*, 1997; Biyalogorsky *et al.*, 2006). Researchers have used experiments to understand precisely what decision rules participants' use in choosing various options (Weber & Camerer, 2006). Moreover, experiments help to analyze the effects of specific information (independent variables) by comparing behavior with and without such information on the dependent variable. The researcher controls the conditions under which the evidence is generated and reports all study details, which helps to replicate the experiment and to falsify the claims made in a particular study. In particular, I used an *experimental conjoint study* and an *experiment* to analyze

decision making processes in the context of innovation portfolio management. I choose these methods for several key reasons:

- Conjoint methodology draws on the assumption that decisions of individuals can be decomposed into their underlying structure (Green, Krieger, & Wind, 2001).
- Conjoint analysis allows researchers to collect data on decisions of individuals as those decisions are being made (Shepherd & Zacharakis, 1997).
- Retrospective methods (e.g., interviews, questionnaires) potentially suffer biases and errors due to inaccurate introspection of participants (Shepherd & Zacharakis, 1997).
- Internal validity can be minimized through controlled experiments, which is essential to establish true causation (Cook & Campbell, 1979), as managers probably do not really know why they made certain decisions in an earlier period.
- Experiments are commonly used to study the phenomenon of escalation of commitment (e.g., Schmidt & Calantone, 2002; Montoya-Weiss & Calantone, 1994).

In the next chapters (B, C, and D) study results are presented. In chapter E, I discuss the major results and a conclusion is drawn¹.

¹ Chapter A is partly based on Coulon, M., Ernst, H., Lichtenthaler, U., & Vollmoeller, J. 2009. An overview of tools for managing the corporate innovation portfolio. *International Journal of Technology Intelligence and Planning*, 5(2): 221–239. This article gives further information about the general topic of innovation portfolio management.

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Chapter B:

Deciding to exploit: the project, the portfolio, and the person¹

1. Abstract

R&D generates projects but how is it decided which projects are to be exploited and which projects are not? Building on the product innovation, portfolio strategy, and managerial psychology literatures, we investigate the inter-related attributes of the product, the portfolio, and the person. We use a conjoint field experiment to collect data on 4032 decisions made by 126 R&D managers to test how project attributes and characteristics of decision makers influence the innovation portfolio. Using hierarchical linear modeling we found that in the decision to exploit, preferred product attributes were immediate access to technology and customers and preferred portfolio attributes were portfolio-fit and market-fit. Of most interest was the finding that with increasing project experience, lower level managers (relative to senior managers) come to value portfolio attributes more and specific project attributes less. These findings have important implications for the R&D management literature.

Keywords: Decision making, R&D project management, experience, portfolio management

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2. Ernst, Holger, Shepherd, Dean A. and Vollmoeller, Judith: "Deciding to exploit: the Project, the Portfolio and the Person", TIE-Tagung, Kiel, November 2010 (in alphabetical order).
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2. Introduction

Firms must find a balance between the continued exploitation of existing products and the exploitation of new products (Cooper, Edgett, & Kleinschmidt, 1999; Girotra, Terwiesch, & Ulrich, 2007; March, 1991). As R&D generates opportunities and given the limited amount of resources (Simon, 1947; Ocasio, 1997), the firm must decide whether or not to exploit a specific innovation project. This is an important yet difficult decision. It is an important decision because the exploitation of new products can be the source of firm rejuvenation, growth, and/or profitability (Song & Parry, 1996). It is a difficult decision because the traditional notions of expected financial reward and risk are shrouded in uncertainty (Knight, 1921; McMullen & Shepherd, 2006). The project exploitation decision - to use a specific project for the innovation portfolio – indicates a significant gap between the research field in innovation management (Shane & Ulrich, 2004; Green, Welsh, & Dehler, 2003, Girotra et al., 2007, Page & Schirr, 2008;) and decision making (Shane & Ulrich, 2004; Green et al., 2003. In the exploitation process, decision makers assess and compare projects based on defined criteria to find an optimal portfolio composition (Cooper, 2008; Hauser, Tellis, & Griffin, 2006; Cooper et al., 1999). Although there has been recent research on managing financial uncertainty using a portfolio approach (Cooper, 2008; Hauser et al., 2006; Cooper et al., 1999), there is reason to suspect that organizational members differ in their exploitation decision based on their positional level within the organization (Floyd & Lane, 2000; Ocasio, 1997). Furthermore, McGrath, Ferrier, and Mendelow (2004, p. 96) noted that “in a multi-project firm there are likely to be major disagreements between those who ‘own the option’ and those who ‘are the option’.” This leads us to the research question of whether decision makers consider project attributes other than projected financial risk and reward? Do they consider projects in the context of their innovation portfolio? How are these decisions influenced by the person making the decision? We build on the project innovation, portfolio strategy, and managerial psychology literatures to investigate the influence of project,

portfolio, and person on the innovation exploitation decision. Specifically, we investigate 4032 assessments, nested in 126 decision makers using a conjoint experiment analyzed with hierarchical linear modeling (HLM).

In doing so, we make the following contributions. Prior research from the product innovation literature has reported that firms rely on the financial attributes of a specific project in deciding whether or not to exploit the project (Cooper et al., 1999) and that this leads to an unbalanced portfolio (Libertore, 1987). Therefore, existing literature is relatively silent on the project attributes other than projected financial risk and reward that managers consider in their exploitation decisions. For that reason, we analyze further specific project characteristics driving the portfolio decision process. Moreover, we analyze person attributes on the decision behavior. Management research has acknowledged that managers at different levels think differently about issues and answers (Floyd & Lane, 2000; Ocasio, 1997; Simon, 1947). We complement these studies by offering new insights into when this might be the case (at least for the project exploitation decision). Finally, and related to the previous point, past research on project exploitation has taken a relatively static perspective, we contribute to the literature on how managers at different management levels influence firm success (Floyd & Lane, 2000; Haleblian & Finkelstein, 1993). Especially, we analyze differences in the decision policies of senior managers in comparison to lower level managers and the effect of specific project experience on the exploitation decision.

The remainder of the paper is organized as follows. In the next section, we describe the specific assessments of project selections based on the characteristics of the project, portfolio, and person. We explain the conjoint research method, sample frame, analyses, and results. Finally, we discuss implications of our model including opportunities for further research.

3. Hypotheses Development

3.1 A Model of the innovation exploitation decision

Building on the project innovation, portfolio strategy, and managerial psychology literatures we develop a model of the innovation exploitation decision. Our model is illustrated in Figure 1. A project is assessed in terms of the likelihood that it will be exploited. That assessment is influenced by attributes of the project (technological and demand considerations) and in the context of strategic aspects (portfolio-fit and market-fit) over and above a set of control variables. Variance in the innovation exploitation decision policy is explained by attributes of the person (project experience, managerial level, and the interaction of the two). Each relationship is detailed in the sub-sections that follow.

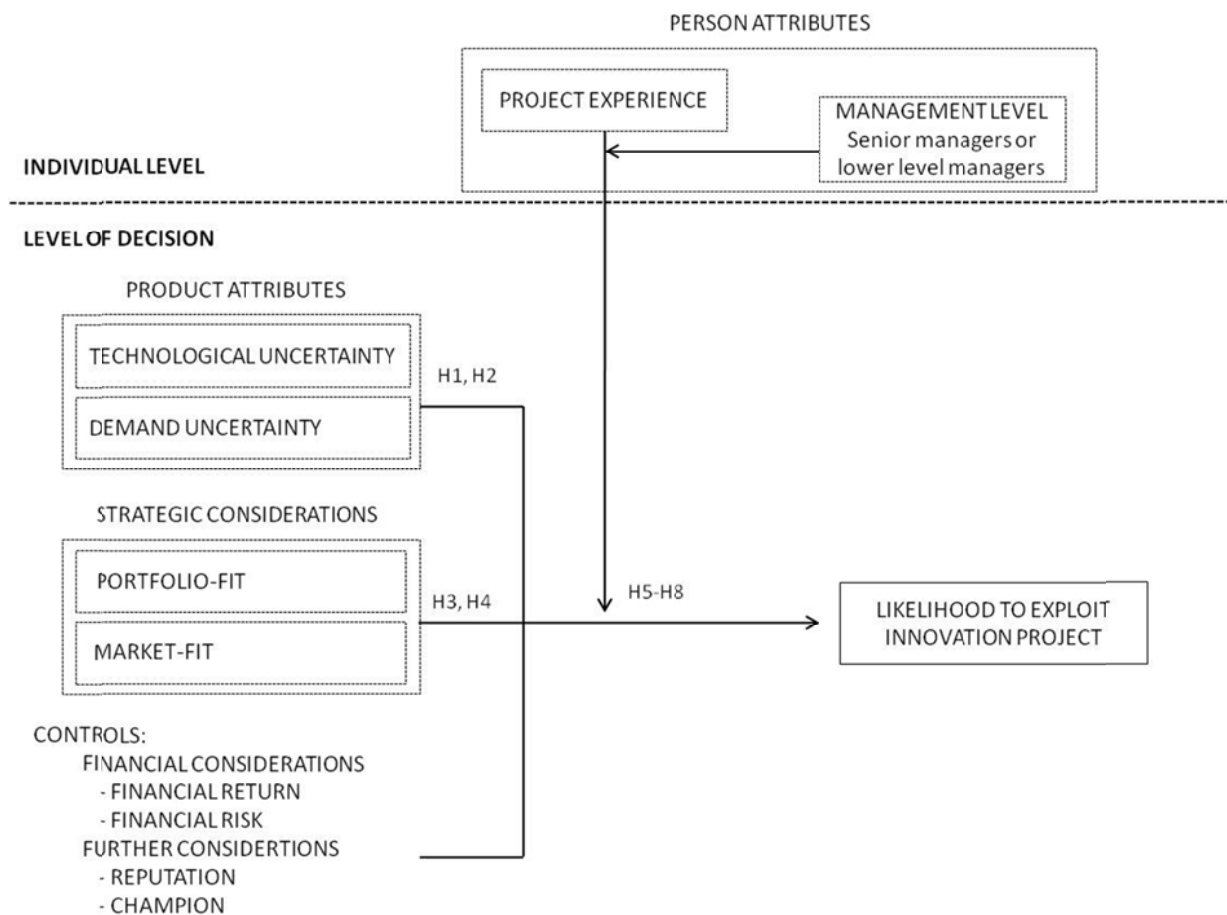


Figure 1: A Model of the innovation exploitation decision

3.2. Project attributes and the decision to exploit

An opportunity enables the creation of future goods and/or discovers and exploits new markets (Venkataraman, 1997). This opportunity can be characterized as the conceptual connection between a technological innovation and market attributes (Sarasvathy, Dew, Velamuri, & Venkataraman, 2003). Technological changes are evaluated as sources of uncertainty (Tushman & Nelson, 1990) and market attributes can be described by consumer preferences which are unstable and change quickly (Wind & Mahajan, 1997). The decision to exploit an opportunity includes evaluating these uncertainty considerations.

Technological uncertainty: If a technology is not completely developed, managers face uncertainty about costs and probability of accomplishing technical success. Technological changes offer new product opportunities for firms; however, these opportunities may quickly become obsolete. Therefore, technology and technological change are consistently seen as sources of uncertainty for organizations (Tushman & Nelson, 1990). Technological uncertainty exists when it is not clear which technology will emerge to lead in the market (Tushman & Rosenkopf, 1992). Firms must choose which technology to embed in their products to fulfill future market requirements (Krishnan & Bhattacharya, 2002). For example, in the automotive industry, a key challenge lies in the timing of an application of a new technology. Firms tend to respond to technology uncertainty by competing on the basis of technology superiority under the assumption that technological advantage is the key to success yet such an approach may not necessarily reflect customers needs (Jaworski & Kohli, 1993, Lichtenthaler & Ernst, 2007). For this reason, technology uncertainty increases the difficulty for managers to analyze the character of technological changes and their implications for customer demand (Tushman & Nelson, 1990). Given that managers (as most people) are typically risk averse (Kahneman & Tversky, 1979), managers need to resolve some of the uncertainty associated by an innovation project decision before deciding to proceed.

Thus,

Hypothesis 1: Decision makers are more likely to exploit a project that is low in technological uncertainty than high in technological uncertainty.

Demand uncertainty: Demand uncertainty refers to the perceived speed of change and unpredictability of customers' product preferences and demands as well as the emergence of new customer segments (Jaworski & Kohli, 1993). Demand uncertainty is mainly associated with the instability of consumer expectations (Zhou, Yim, & Tse, 2005) and is amenable for interpretation (Atuahene-Gima & Li, 2004). Customer demand partly depends on whether customers are familiar with the new product and find it valuable (Aldrich & Fiol, 1994). Consumer preferences can be unstable and change quickly for new products (Wind & Mahajan, 1997). Therefore, managers like to reduce demand uncertainty while deciding, as they are usually risk averse decision makers (Kahneman & Tversky, 1979). The pursuit of an opportunity (entrepreneurial action) is undertaken in environments of high uncertainty (the entrepreneur typically perceives high uncertainty about the attractiveness of the opportunity and must determine how much uncertainty his or her firm is willing to bear) (McMullen & Shepherd, 2006). For this reason, decision makers consider the amount of demand uncertainty surrounding of a project when deciding whether to exploit that project. Thus,

Hypothesis 2: Decision makers are more likely to exploit a project that is low in demand uncertainty than high in demand uncertainty.

3.3. Strategic attributes and the decision to exploit

A firm's new project strategy defines the role of new product development in the firm's overall strategy (Cooper & Kleinschmidt, 1995a, Henard & Szymanski, 2001). Specifically, an explicit project innovation strategy allows management to focus on specific project developments as they relate to existing projects, and this approach is believed to result in better performing new product portfolios (Cooper & Kleinschmidt, 1995a). The strategic factors influencing project success are characterized by attributes of portfolio-fit and market-

fit (e.g., Song & Parry, 1996, Henard & Szymanski, 2001, Cooper et al., 1999, Montoya-Weiss & Calantone, 1994).

Portfolio-fit: The allocation of a firm's resources to a limited number of innovation projects constitutes an important strategic decision to achieve a firm's goals in its innovation activities (Griffin, 1993). Consequently, innovation portfolio management helps firms to achieve an effective and efficient allocation of resources. The innovation portfolio management process is directed at optimizing a firm's innovation portfolio with particular emphasis on managing the "right" innovation projects (Cooper et al., 1999). Moreover, the objective of the portfolio management system is to turn the business strategy into a dynamic set of innovation projects; the entire mix of projects and new products needs to be taken into consideration (Cooper, Edgett, & Kleinschmidt, 2001). Thus, portfolio-fit involves the value maximization and balance within the portfolio (Cooper, 1999). Therefore, portfolio-fit decisions are a connection between a firm's innovation activities and the firm's strategy. Although these decisions are based on individual project characteristics, they are also made in the context of the whole portfolio and the organization's strategic goals. Thus, portfolio management drives a firm to continuously update and reconfigure its list of active innovation projects to improve the overall value of the firm (Cooper et al., 1999). Thus:

Hypothesis 3: Decision makers are more likely to exploit a project that has a high portfolio-fit than a low portfolio-fit.

Market-fit: An explicit strategic competitive advantage of an innovation project can be gained when it has a high market-fit (Kohli & Jaworski, 1990). Market-fit of the project can help build market share and competitive advantage (Sarin & Mahajan, 2001). With regard to the actual development process, analyzing competitive advantages assumes special value of project performance as price, quality or service of the project (Montoya-Weiss & Calantone, 1994). Hence, the general relationship between market-fit and portfolio-fit is based on the assumption that a firm describes and implements a specific competitive strategy to maximize

the values of its capabilities (Cooper et al., 1999; Song & Parry, 1996). Through the greater understanding of customer needs and competitive advantages firms are more likely to develop new projects that match their current skills and resources. Thus:

Hypothesis 4: Decision makers are more likely to exploit a project that has a high market-fit than a low market-fit.

3.4. Managerial level, experience, and project consideration

Hambrick and Finkelstein (1987) introduced the concept of managerial discretion (latitude of action) as a way to resolve the ongoing debate about whether managers influence firm outcomes. Managerial discretion refers to the room of actions managers have in making strategic choices (Haleblian & Finkelstein, 1993). Managerial discretion can be represented at different levels; at the individual (e.g., Finkelstein & Peteraf, 2007), the environmental (e.g., Haleblian & Finkelstein, 1993), and/or the organizational level (e.g., Hambrick & Finkelstein, 1987). Where discretion is high, managers can drastically influence the organization and managerial characteristics will be reflected in organizational outcomes (Finkelstein & Hambrick, 1990; Finkelstein & Peteraf, 2007).

Although managers at all levels influence firm success, the roles of senior managers and lower level managers differ in their time horizon, information requirements, and core values (Floyd & Lane, 2000). Senior managers' jobs are to ratify, to delegate, and to recognize action plans (Floyd & Lane, 2000). They build a vision of the future of the firm by searching for new ideas to maximize firm performance over the long run. The lower level managers' role is to experiment, to adjust, and to conform (Floyd & Lane, 2000) as, for instance, they link technical ability and need, respond to the challenge and follow the system.

Furthermore, lower level managers and senior managers likely differ in the role of experience on their decision making. Studies document that senior managers routinely make decisions based on experience (Agor, 1986; Giunipero, Dawley, & Anthony, 1999). The functional background experience of managers reflects their job history within organizations

or industries. Therefore, more experienced managers should be better able to recognize the benefits and potential pitfalls of innovation projects to help improve firm performance. As people are usually risk averse (Kahneman & Tversky, 1979) they typically like to exploit innovation projects that are low in uncertainty. On this account, when a decision is made under technological and demand uncertainty, not all decision outcomes can be identified by the decision maker in advance.

The perception of environmental uncertainty varies by management level (Ireland, Hitt, Bettis, & De Porras, 1987), for example, managers have access to different environmental information. Human capital theory (Becker, 1962) suggests that more experienced lower level managers will perform better than lower level managers new to a job. They learn to focus on key dimensions of the task (Chase & Simon, 1973) and are able to create stronger links between concepts (Gobbo & Chi, 1986). More experienced decision-makers are able to make use of superior decision processes relative to those with less experience (Anderson, 1983).

Senior managers appear to be more careful decision makers whereas lower level managers make faster decisions that lead to a greater number of mistakes (Forbes, 2005). Further, senior managers are likely more used to making decisions under uncertainty as they have learned how to “deal with” missing information and to be aware of associated decision errors (Tubbs, 1992). Furthermore, as senior managers already have a reputation within the company (Forbes, 2005), they have more to lose if an exploitation decision goes wrong. With more to lose with a decision that turns out badly, senior managers are likely to exploit innovation projects that are lower in uncertainty to minimize their personal career risk.

Thus,

Hypothesis 5:

(a) Decision makers with greater experience place less emphasis on technological uncertainty than decision makers with lesser experience.

(b) The negative relationship between experience and emphasis on technological uncertainty is more negative for lower level managers than for senior managers.

Hypothesis 6:

(a) Decision makers with greater experience place less emphasis on demand uncertainty than decision makers with lesser experience.

(b) The negative relationship between experience and emphasis on demand uncertainty is more negative for lower level managers than for senior managers.

3.5. Managerial level, experience, and strategic considerations

Experience offers better understanding of details and nuances of tasks and situations (Chase & Simon, 1973) and enhances learning (Cohen & Levinthal, 1990; Gioia & Manz, 1985; Zahra & George, 2002; Lichtenthaler, 2009). While the learning curve literature (e.g., Levitt & March, 1988; Sampson, 2005) has shown that firms improve production effectiveness with increased experience, the same arguments can be applied to identify the role of experience with R&D selection and project exploitation. In other words, experience helps to make diversified and strategic project decisions (Levitt & March, 1988). Indeed, the amount of experience has been found to be directly related to job outcome (Schmidt, Hunter, & Outerbridge, 1986).

Therefore, more experienced managers know how to handle strategic information as they are already able to recognize the pros and cons of an innovation project. Experienced senior managers intuitively make an appropriate exploitation decision (Leybourne & Sadler-Smith, 2006).

In contrast, lower level managers need to look for strategic signals as portfolio-fit and market-fit. Their role within the organization (Floyd & Lane, 2000) does not give them the discretion (Finkelstein & Hambrick, 1990) to decide against strategic / promising indicators. They concentrate on “fit-aspects” of an innovation project which is for them a key factor that increases project success (Song & Parry, 1996). Experience has a positive impact on job effort

when lower level managers have relative low tenure and are still learning their job (Schmidt & Hunter, 2004). More experienced lower level managers learn that strategic fit of an innovation project is a high-quality predictor; therefore, they exploit it to observe portfolio synergies related to “fit”. Specifically, the more project experience a lower level manager gains the more emphasis he or she places on strategic considerations such as portfolio-fit and market-fit, because they learned to estimate strategic connections and to evaluate “fit” as an important factor. Thus,

Hypothesis 7:

- (a) Decision makers with greater experience place more emphasis on portfolio-fit than decision makers with lesser experience.
- (b) The positive relationship between experience and emphasis on portfolio-fit is more positive for lower level managers than for senior managers.

Hypothesis 8:

- (a) Decision makers with greater experience place more emphasis on market-fit than decision makers with lesser experience.
- (b) The positive relationship between experience and emphasis on market-fit is more positive for lower level managers than for senior managers.

4. Research Method

4.1. Sample and data collection

Our sample consists of senior managers and lower level managers working in German firms, who are involved in the decision making processes of innovation projects. We identified the largest firms (in terms of turnover) in different industries using the Hoppenstedt Database, as larger firms have a higher R&D intensity (Hashai & Almor, 2008). We contacted 284 persons via telephone and asked for participation (if they were involved in innovation project/portfolio decisions within their firm). In case they agreed to participate, we explained the purpose of the study. After two weeks, if they had not yet participated, we reminded them via email and/or by telephone. As an incentive, every participant was promised a customized report with study results and was placed in a lottery with the chance to win an Ipod nano. Furthermore, all participants were invited to a workshop presenting results about the topic

“innovation portfolio management” arranged at WHU-Otto Beisheim School of Management in Vallendar. All together, we ended up with 126 participants representing a response rate of 44% (in terms of firms contacted), which is encouraging given the time pressure and work load reported by most participants. We collected data on the characteristics of participants and the organization for which they work. The participants were on average 39 years old (standard deviation 10.08), 86.7% were male, 41.3% had a degree in engineering, 22.2% in natural science, 21.4% in business studies while the rest (15.1%) had a combination, e.g. background in business studies and engineering. 29.6% worked in the chemistry industry, 27.8% in the mechanical engineering industry, 17.5% in the electronic industry and 25.1% worked in different industries (most in consumer goods industry). On average, the participants worked for their current firm for 10 (standard deviation 13.15) years.

4.2. Conjoint Analyses

We used a metric conjoint analysis to collect data on the manager’s likelihood to exploit an innovation project. Conjoint studies require decision makers to make assessments based on a number of attributes representing the research variables. These attributes are described by two levels (i.e., high or low). Conjoint methodology draws on the assumption that decisions of individuals can be decomposed into their underlying structure (Green, Krieger, & Wind, 2001). Conjoint analysis allows researchers to collect data on decisions of individuals as those decisions are being made. This is in contrast to retrospective methods (e.g., interviews, questionnaires), which potentially suffer biases and errors due to inaccurate introspection of participants (Shepherd & Zacharakis, 1997). In the conjoint experiment, participants are first provided with a description of the decision situation. Afterwards, they are presented with decision profiles each representing a specific innovation project. The experiment also contained a post-experimental questionnaire, which we used to collect the demographic data of participants and their respective firms. The data collection instrument included a cover letter with instructions which guided them through the experiment, one page

defining all attributes and levels contained in the study, 33 profiles, and a post-experiment questionnaire. A sample profile is offered in the appendix.

4.3. Research variables at level 1 and level 2

Level 1: The judgments of the decision makers represent the *dependent variable*, whereas the attributes describing the decision scenario constitute the *independent variables* and *control variables*. The dependent variable of our study is the manager's likelihood to exploit an innovation project. We asked managers to assess the attractiveness of exploiting a specific innovation project into the portfolio on a seven-point Likert-type scale from "1= very unlikely" to "7= very likely". The scenarios in our experiment are described by eight attributes, each of which is described by two levels.

Decision attributes: The decision attributes in this experiment were presented with eight attributes describing specific characteristics of an innovation project. The first four were created based on the related framework. *Technological uncertainty* means that the access of the technological knowledge exists already in the firm or is totally new for the described innovation project. *Demand uncertainty* stands for an existing customers' option or for no customer demand before the innovation project should be added into the portfolio. *Portfolio-fit* describes the level of adaption of the innovation project into the innovation portfolio of a firm and ranges from a well fit to partly fit into the innovation portfolio. *Market-fit* means that the innovation project provides, in comparison to other products on the market, either an explicit strategic competitive advantage for the firm, or has a low value.

We added four control variables, to manage further influence factors in the decision making process. First, we added *financial rates* which can be very positive or below average. Financial rates range from ranking or selecting projects based on traditional net present value through various financial indices. Furthermore, we subjoined *risk*, which is the probability of an expected positive or negative value. Risk can be estimated as low or as high. Moreover, the support of an active top-management member, by name champion, who can support the

innovation project or respectively not support it. Positive (versus negative) *reputation*, meaning that the lower level manager and his team have (un-)successfully managed innovation projects in the past.

Level 2: Moderator variables: In the post-experimental questionnaire we collected data on the specific *position* of the participant, which can be a (top-) management position (senior managers) or a lower level manager position. Moreover, information on the *experience* about project decision making, was measured by the number of managed innovation projects in the past. In this study, we measured the degree of experience by the number of innovation projects participants managed in the past. The participants managed on average 15 innovation projects (standard deviation is 32 innovation projects, maximum 200 innovation projects). In order to control for potential industry effects, we added industrial dummies. Therefore, at level 2 the coefficients of the decision attributes becomes the dependent variable, experience is the independent variable, and industry dummies are the control variables.

4.4. Conjoint Design

The profiles of our study are described by eight attributes, each of which is represented by two levels. Since a fully crossed, factorial design involving eight factors at two levels (2^8) requires 256 profiles; assessing 256 profiles would be an overwhelming task for the respondent; we applied an orthogonal factorial design to reduce the number of attribute combinations to 16 and collected judgments of 16 different attribute combinations from each participants (Hahn & Shapiro, 1966). We confirmed reliability of decision makers' judgments by replicating profiles and performing test-retest checks (Shepherd & Zacharakis, 1997). Full replication of all 16 attributes combinations of our experimental design resulted in 32 profiles, we randomly assigned the 32 profiles as well as the profiles resulting in two versions of the experiment. In order to test for possible order effects, we compared the mean score across the different versions and found no significant difference. Furthermore, as a first task we included

a practice profile. Participants should become familiar with their task before they start the experiment. This practice profile was not included in the analysis.

4.5. Statistical Method

Data consists of 32 assessments for each of the reliably answering 126 participants, yielding 4032 data points. This total number is consistent with other conjoint studies using a similar design (Patzelt & Shepherd, 2008; Shepherd, 1999). While there are a larger number of degrees of freedom for subsequent analyses, there may be autocorrelation because the 4032 observations are nested within 126 individuals. The appropriate method to account for this nested nature of data is hierarchical linear modeling (HLM). HLM allows us to parcel out variances at level 1 (the decision) and level 2 (the individual) and accounts for the possible impact of autocorrelation. It allows us to focus exclusively on the effect of the decision attributes while controlling for other factors that are different across persons and organizations.

5. Results

Our study yielded 126 responses. For all analyzes the variables are standardized and group centered. The mean test-retest correlation was .72, which is similar to other studies (Shepherd, 1999; .69). The mean R^2 of the individual models was .78, similar to previous work (Shepherd, 1999; .78). This demonstrates that the conjoint task was performed consistently by the participants. We report the results in Table 1.

Table 1: Managers' likelihood to exploit R&D project in the innovation portfolio

Evaluation criteria	Level 1 effects on DV		
	Intercept Coefficient	Standard Error	t-ratio
Intercept	3.599***	0.046	78.768
Technological uncertainty	0.606***	0.038	15.889
Demand uncertainty	1.107***	0.048	23.051
Portfolio-fit	0.537***	0.048	11.155
Market-fit	1.116***	0.047	23.721
Financial rates	1.134***	0.063	17.983
Risk	0.850***	0.040	21.060
Reputation	0.612***	0.057	10.594
Champion	0.657***	0.045	14.458

Dependent variable (DV): Manager's decision to exploit innovation project

Level 1 analysis: Decision = β_0 + β_1 Technological uncertainty + β_2 Demand uncertainty + β_3 Portfolio-fit + β_4 Market-fit + β_5 Financial rates + β_6 Risk + β_7 Reputation + β_8 Champion

*** $p < .001$, ** $p < .01$, * $p < .05$; $n=4032$ decisions nested within 126 managers

All variables are standardized and group centered.

Level 1 effect: In Table 1 are the coefficients, the corresponding standard errors, t-ratio and levels of significance for the main effects on the dependent variable on level 1 presented. The first column reports the decision factors, the next columns report the results for the intercept model. Our results reveal significant main effects for all eight attributes (effect on Level 1 on dependent variable). Specifically, the positive coefficient for technological uncertainty supports hypothesis 1. It shows that decision makers, over and above financial return and risk, are more likely to exploit a project that uses technologies that are familiar to their firm. The positive coefficient for demand uncertainty supports hypothesis 2. Thus, decision makers are more likely to exploit a project that is low in demand uncertainty than high in demand uncertainty. The positive coefficient for portfolio-fit and market-fit supports hypotheses 3 and 4, respectively. Specifically, decision makers are more likely to exploit a project that has a high portfolio-fit and a high market-fit.

Interaction effects between level 1 and level 2: We also report the corresponding values for level 2 variables, which account for variance across individuals. These values represent interactions between Level 2 and the respective Level 1 variables, see Table II. They indicate how the relationship between the Level 1 variable and the dependent variable is contingent on individual characteristics captured at Level 2. Table II shows the results for position, experience and the interaction effects between position, experience on technological- and demand uncertainty as well on portfolio-fit and market-fit. The table shows that all interaction effects are significant. To interpret the nature of the significant interactions, we plot each relationship. On the y-axis is the emphasis (weight) on the decision attribute and the x-axis represents the level of experience. In each graph we plot separate lines for the management level, either high or low. Figure 2a – 2d illustrates the interactions.

Table 2

Table II: Interaction effects between Level 2 and Level 1 variables on DV

Evaluation criteria	Position			Experience			Interaction: Position and Experience		
	Coefficient	Standard Error	t-ratio	Coefficient	Standard Error	t-ratio	Coefficient	Standard Error	t-ratio
Intercept	0.273*	0.107	2.560	- 0.554	1.756	- 0.315	2.052	1.939	1.058
Technological uncertainty	- 0.019	0.092	-0.202	0.106	1.176	0.090	-3.822**	1.312	-2.913
Demand uncertainty	- 0.063	0.121	0.603	2.561	3.108	0.824	-9.604**	3.239	-2.965
Portfolio-fit	- 0.176	0.118	-1.487	- 0.360	2.285	- 0.158	8.085***	2.466	3.278
Market-fit	- 0.146	0.116	-1.259	0.113	1.347	0.084	8.345***	1.587	5.257

Dependent variable (DV): Manager's decision to exploit innovation project

Level 1 analysis: Decision = β_0 + β_1 Technological uncertainty + β_2 Demand uncertainty + β_3 Portfolio-fit + β_4 Market-fit + β_5 Financial rates + β_6 Risk + β_7 Reputation + β_8 Champion

Level 2 analysis: β_1 (from level 1 analysis) = intercept + position + experience + position X experience + industry chem. + industry elec. + industry mach.

*** p < .001, ** p < .01, * p < .05; n=4032 decisions nested within 126 managers

All variables are standardized and group centered.

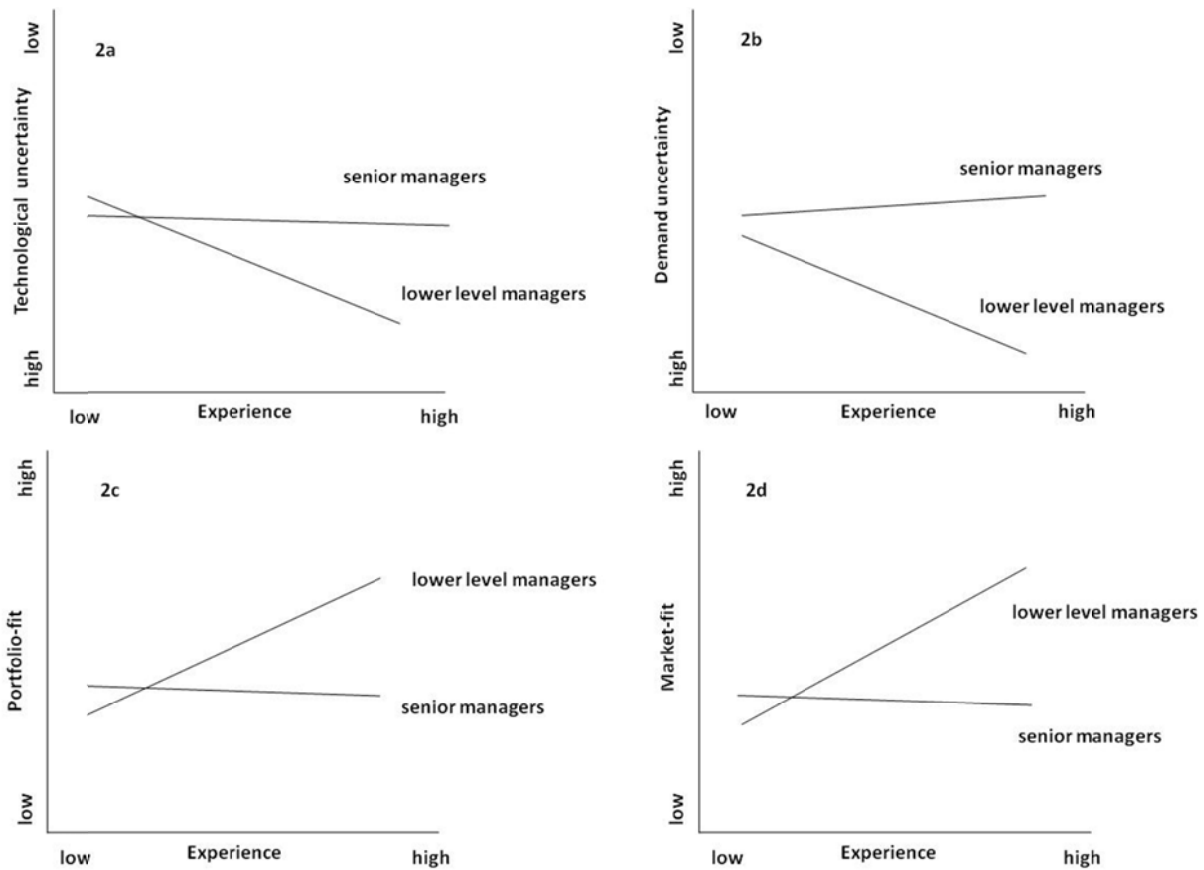


Figure 2: Moderating relationships between (a) Technological uncertainty (b) Demand uncertainty (c) Portfolio-fit (d) Market-fit and experience. For each control variable, senior managers and lower level managers are represented in separate lines.

In the analyses above, Figure 2a shows that decision makers with greater experience place less emphasis on technological uncertainty than decision makers with lesser experience, and that, the relationship between experience and emphasis on technological uncertainty is more negative for lower level managers than senior managers. This finding provides support for hypothesis 5a-b.

Figure 2b shows that decision makers with greater experience place less emphasis on demand uncertainty than decision makers with lesser experience, and that, the relationship between experience and emphasis on demand uncertainty is more negative for lower level

managers than senior managers. The nature of this significant interaction provides support for hypothesis 6a-b.

In the analyses above, Figure 2c shows that decision makers with greater experience place more emphasis on portfolio-fit than decision makers with lesser experience, and that, the relationship between experience and emphasis on portfolio-fit is more positive for lower level managers than senior managers. This finding provides support for hypothesis 7a-b.

Figure 2d shows that decision makers with greater experience place more emphasis on market-fit than decision makers with lesser experience, and that, the relationship between experience and emphasis on market-fit is more positive for lower level managers than senior managers. The nature of this significant interaction provides support for hypothesis 8a-b.

6. Discussion and Contribution

This study focuses on decision making in the context of innovation portfolio management. It extends the literature on product innovation, portfolio strategy and managerial psychology. So far, most studies have analyzed factors of successful innovation management (e.g., Song & Parry, 1997b). These studies have identified tactical and environmental factors that influence the commercial success of new products (Song & Parry, 1997a). Moreover, a body of literature has investigated the role of innovation portfolio management (Cooper et al., 1999; Cooper et al., 2001). These studies focus on innovation portfolio management as picking the right innovation projects for the overall innovation portfolio. Financial methods are the most popular decision making approaches; however, they yield the poorest innovation portfolio results (Cooper et al., 1999). In line with previous decision making literature on innovation project management and innovation portfolio management, our article emphasizes the impact of specific project attributes on the decision making behavior (e.g., Chao & Kavadias, 2008; Cooper et al., 1999; Girotra et al., 2007) and complements these studies by analyzing further specific considerations while exploiting an innovation project. Especially,

we focus on strategic- and uncertainty considerations and include project experience and managerial level in the observation.

Decision makers prefer to exploit innovation projects that are low in uncertainty considerations. As technological changes are the base of uncertainty (Tushman & Nelson, 1990) and market characteristics are often unsteady and change quickly (Wind & Mahajan, 1997), we analyzed technological- and demand uncertainty considerations in this experimental conjoint analyses. Our results underline that managers like to exploit innovation projects that fulfill future technological market requirements and are therefore low in technological uncertainty. In addition, as decision makers are usually risk averse (Kahneman & Tversky, 1979), they also like to exploit innovation projects with a low demand uncertainty (instability of consumer expectations) (Zhou et al., 2005). Moreover, our results demonstrate that decision maker's exploit innovation projects that are high in strategic attributes. The strategic aspects were characterized by the attributes of portfolio-fit and market-fit (Song & Parry, 1996; Henard & Szymanski, 2001; Cooper et al., 1999; Montoya-Weiss & Calantone, 1994). Managers like to exploit innovation projects with a high portfolio-fit, this means, they value the connection between a firm's strategy and a firm's innovation activity as a promising indicator in the exploitation process. Additionally, managers exploited innovation projects with a high market-fit. For decision makers it is important that the innovation project gains a high market share and a competitive advantage in the future (Sarin & Mahajan, 2001).

Our results further show, that a change in decision policy depends on experience (Agor, 1986; Giunipero et al., 1999). We find that while there are few differences in decision policy between inexperienced senior managers and inexperienced lower level managers, significant differences exist at higher levels of experience. Especially, it demonstrates that project experience makes little difference to senior managers, but significant difference to lower level managers. Moreover, we find that senior managers and lower level managers focus on fit aspects; however, they do so with different intensity. We illustrate that lower level

managers with more experience (relative to senior managers) concentrate more on strategic fit aspects and less on uncertainty considerations. This underlines that the concept of managerial discretion (Hambrick & Finkelstein, 1987) has an impact on the exploitation decision; particularly, since the role of senior and lower level managers differs in their time horizon, information requirements, and core values (Floyd & Lane, 2000).

In addition, our study has implications for practice. The results of our study can help senior managers and lower level managers better understand their own strategic decisions and therefore can improve their own decision behavior in the future. Specifically, lower level managers exploiting innovation projects are strongly influenced by experience. Therefore, especially lower level managers have a variance in the decision behavior. If a firm wants to improve the overall innovation portfolio of a firm, they should have a combined decision making team of senior managers and lower level managers, to gain the best decision results. Moreover, this study is useful to others, who work with decision makers within a firm, because it provides directions to decision behavior that can be gleaned from a basic individuals profile. These directions can aid to understand how senior managers and lower level managers are likely to control for strategic issues of an innovation project. Managers in having this consideration will be better able to advice and to infer the strategic behavior of co-workers.

7. Limitations and Future Research

Implications for future research arise from the limitations of our study. We analyzed the decision process of individual managers. Future research is needed to investigate team dynamics in the decision making process. The interrelated decision making processes within a team is an interesting research topic for future work. Furthermore, we performed our study in an explicit setting: innovation managers in large and medium firms in the chemistry, mechanical engineering and electronic industry in Germany. Future research must analyze, if our findings can be generalized across countries and smaller firms with a smaller innovation

portfolios and managers with less experience in portfolio management. Moreover, the specific management position in an innovation department in comparison to, e.g., a marketing position can have an impact on decision making processes within an organization. Future research should further investigate these differences. Also, different kind of experience, e.g., industry experience or general working experience may also determine the decision making process of an individual. Future research can make additional contributions by studying variance in experience levels.

Finally, we would like to mention methodological limitations. The orthogonal design does not account for potential correlations between variables, anyhow, it has the advantage of leading to more robust results (Huber, 1987). Second, questions about external validity of experiments should be involved, because the assessments are based on a few limited attributes; decisions in the business world are often more complex. A participant can use attributes just because they were presented in the experiment. However, there is evidence that even in the most artificial situations conjoint analyses reflect the decision policies actually used by decision makers. Studies show that conjoint analyses replicate real-world judgments of individuals (Hammond & Adelman, 1976). The attributes of this study were theoretically justified and pilot tested. Moreover, we conducted ten in-depth interviews with R&D-managers from different branches to verify the importance of the specific attributes of the experiment. The interview partners underlined the importance of the chosen project characteristics while making a project selection decision.

The scenarios in our conjoint experiment describe only one point in time, but decision making in the context of innovation portfolio management is a dynamic process, whereby a firm's list of active new product projects is constantly updated and revised (based on e.g., Cooper et al., 2001; Griffin, 1993; Graves, Ringuest, & Case, 2000; Ringuest, Graves, & Case, 1999). During this process, new projects are evaluated, selected, and prioritized. The

dependent variable only analyzes the likelihood to exploit an innovation project. Future experiments should analyze the dynamics between go/stop-decisions.

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Appendix: Wording experiment value explicit

Attribute	Characteristic	Definition
1 Technological uncertainty	low	The technology of the innovation project already exists in the company.
	high	The technology of the innovation project is new for the company.
2 Demand uncertainty	low	There is a specific customer's option.
	high	There are still no customers for the project
3 Portfolio-fit	high	The innovation project fits well into the overall innovation portfolio.
	low	The innovation project partly fits into the innovation portfolio.
4 Market-fit	high	The innovation project has a clear strategic competitive advantage.
	low	The innovation project has no strategic competitive advantage.
5 Financial rate	positive	The financial rates of the innovation project are positive.
	negative	The financial rates of the innovation project are below average.
6 Risk	low	The risk of the project is estimated as low.
	high	The risk of the innovation project is estimated to be high.
7 Reputation	positive	The project leader and his team have managed successful innovation projects in the past.
	negative	The project leader and his team have managed unsuccessful innovation projects in the past.
8 Champion	existing	The innovation project is supported by an active champion in the top management.
	non existing	The innovation project is not supported by an active champion in the top management.

Chapter C:

What keeps managers away from a losing course of action? - “Go-/stop-decisions” in new product development¹

1. Abstract

The purpose of this 4x2 experiment is to test whether specific approaches can reduce escalation of commitment, that is, the tendency of decision makers to persist with an innovation project in spite of negative feedback that the initial investment has not reached its goals. This study focuses on the decision process while 137 R&D managers must decide whether to abandon the previously chosen course of action or to continue in the face of probable and increasing losses in a stage gate system. Results show that visual decision aids and the advice of a consultant reduce to continue funding a losing course of action. There is also a tendency that using both approaches gains the strongest effect. Finally, the study shows that the escalation of commitment problem can better be reduced before an innovation project is commercialized while using both approaches.

Keywords: escalation of commitment, go/stop-decisions, new product development, experiment.

¹ Based on the following conference presentation:

Vollmoeller, Judith and Ernst, Holger: “Go-/stop-decisions: Techniques for reducing commitment to a losing course of action”, PDMA: 34th annual global conference on product innovation management, Orlando (USA), October 2010.

2. Introduction

The decision to terminate an ongoing innovation project is not an easy one. Project termination is one of the most difficult decisions to make in practice (Balachandra, Brockhoff, & Pearson, 1996; Calantone, Di Benedetto, & Schmidt, 1999). Managers become psychologically committed and invest in their initially-chosen (losing) course of action (Brockner & Rubin, 1985; Staw, 1976; Teger, 1980). Various studies show how individuals can become locked in failing courses of action, which was studied under the rubrics sunk cost effect (Arkes & Blumer, 1985), entrapment (Brockner & Rubin, 1985), too much invested to quit (Teger, 1980) and escalation of commitment (Staw, 1976). Escalation of commitment to a failing course of action is an enduring problem that remains central to the study of managerial behavior. Escalation of commitment, has been used to explain poor decision making in a variety of contexts, including sports drafts, business mergers, military decisions, software projects, politics and gambling (e.g., Staw, 1976; Brockner & Rubin, 1985; Staw, Barsade, & Koput, 1997). In addition, in the context of new product development (NPD) studies have contributed to our understanding of commitment to a losing course of action (Boulding, Morgan, & Staelin, 1997; Biyalogorsky, Boulding, & Staelin, 2006); however, Schmidt & Calantone (2002, p. 105) remind us that “the mechanism of escalation of commitment remains relatively unknown and under researched.”

In escalation situations, decision makers find themselves confronted with negative feedback concerning a previously chosen course of action and must decide whether to persist with or withdraw from the previously chosen course of action (Brockner, 1992). Escalation of commitment appears, e.g., when there is a need to justify a past investment (Brockner & Rubin, 1985), if managers do not want to waste a previous investment (Arkes & Blumer, 1985) and if managers complete or terminate an unfinished project (Garland, 1990). One leading explanation for escalation of commitment is the decision makers' need for self-

justification. Decision makers are unwilling to dismiss previous decisions because doing so admits (to themselves or others) that their earlier decision was a mistake (Brockner, 1992). Surprisingly, failures and negative feedback often do not minimize commitment, nor do they lead to a different action plan (Staw & Fox, 1977).

Several recent studies showed that escalation of commitment is a promising theoretical framework for explaining and testing decision making processes in a new product development setting (Boulding et al., 1997; Schmidt & Calantone, 2002; Biyalogorsky et al., 2006). While most escalation of commitment studies seek to understand why decision makers increase commitment to a failing course of action, this study analyzes how decision makers relieve themselves from the escalation of commitment trap. Based on the new product development and the escalation of commitment literature, we explain decision makers' tendency to a losing course of action and test if the advice of a consultant (approach one) and visual decision aids (approach two) reduce this phenomenon. Especially, we analyze these approaches to help decision makers to improve their project decisions and to fill existing research gaps. Especially, we follow the proposal by Biyalogorski et al., (2006, p. 118) who recommended "change the organizational structure such that continue/stop decisions are made by someone with no prior beliefs about the project" (an external consultant) to reduce the escalation of commitment phenomenon. Furthermore, we analyze visual decision aids e.g. tools and graphs, which help to fund the wrong innovation projects (Cooper, Edgett, & Kleinschmidt, 1999). These two approaches could potentially aid managers in stay away from over-commitment of resources. Finally, these approaches might help managers to invest resources in more profitable opportunities. We, moreover, extend the literature on decision making studies while analyzing these approaches along the stage gate process (e.g. Boulding et al., 1997, Biyalogorsky et al., 2006, Schmidt & Calantone, 1998; Schmidt & Calantone, 2002). As poor success rates of new products are often results of unprofitable decision making

processes in a stage gate system (Page, 1993; Wind & Mahajan, 1997), we test approaches for reducing the escalation of commitment trap along the decision process. Past research on repeated investment decisions has generally not considered which approaches are most effective during several decision making periods (Garland, 1990; Simonson & Staw, 1992; Schmidt & Calantone, 2002; Tan & Yates, 2002). Accordingly, this study focuses on the decision process while research and development (R&D) managers made a product launch decision and a subsequent reevaluation decision in a stage gate system. Specifically, we design a 4x2 experiment with 137 R&D managers and test our hypotheses by using a unique data set as usually the participants in experiments are MBA-students and not managers.

The remainder of the paper is organized as follows. We begin by discussing the well-known new product development process and the phenomenon of commitment to a losing course of action. We discuss general strategies for reducing escalation of commitment and develop research hypotheses. We explain the research method, sample frame, analyses and results. Eventually, we discuss implications of our arguments for the new product development literature and present a conclusion, including future research approaches for improving decision making and decreasing escalation of commitment.

3. Hypotheses Development:

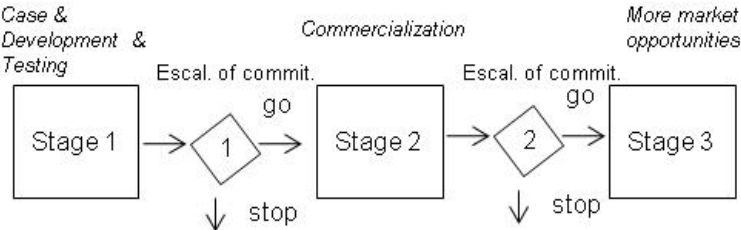
Reducing escalation of commitment in the new product development process

Escalation of commitment to a losing course of action is an enduring phenomenon of great significance, that is, “good money chasing bad” (Simonson & Staw, 1992). Following Staw & Ross (1987), we define escalation of commitment as the continuation in a losing course of action. Commitment usually is connected to sunk costs and framing effects. Decision makers frame the current decision relative to prior loss (Whyte, 1986). Especially, behavioral decision theory research (Tversky & Kahneman, 1974) analyzes decision makers systematic departure from rational prescriptions of economic models. If prospect theory is in

effect (framework for analysis of choice under risk) the decision maker will gamble more to make up earlier investment decisions (Kahneman & Tversky, 1979). In other words, the decision maker sticks with despite information that indicates the outcome is unlikely to be successful. Most escalation of commitment studies focused on the influence factors of it (Brockner & Rubin, 1985; Staw, 1976; Teger, 1980). Comparatively little is known about the approaches under which escalation of commitment can be reduced (Ku, 2008). We still have limited information about how managers use information, evaluate projects, and make critical termination decisions in a stage gate system (Balachandra et al., 1996; Schmidt & Calantone, 2002).

A stage gate system is an idea to launch system (Cooper, 2008; Griffin, 1997). The stages are composed of various activities as marketing, technical or financial analysis, necessary to generate information and transform ideas into products (Schmidt & Calantone, 2002). The gates are used as review points where managers make continuation / “go” decisions (if the project shows signals of success) or termination / “kill” decisions (if the project shows signals of failure). They are important checkpoints in this experiment. (For details see figure 1). The information gained during the stage gate process is used to forecast potential success and failure performances of the product. At the gates, innovation projects are prioritized and essential resource commitments are made.

Figure 1: Escalation of commitment in the new product development process



In this study, we focus on several approaches that might reduce the escalation of commitment phenomenon. One approach is to reduce those factors that have been previously

identified to underline escalation tendencies as personal involvement (e.g.; Boulding et al., 1997; Keil & Robey, 1999; Staw & Ross, 1987) by introducing the advice of an external consultant in the decision making process. We use this approach as external consultants are least personal involved in the decision making process and therefore can help to objectify project information (e.g.; Keil & Robey, 1999; McNamara, Moon, & Bromiley, 2002; Bolton, 2003; Staw & Ross, 1987). The second approach capitalize on the fact that most escalation of commitment research has reflected on the sunk cost effect (Arkes & Blumer, 1985; Staw, 1976). Hinds mapped by visual decision aids (graphical decoding of information) might help to underline the sunk cost effect of an unprofitable investment decision. Therefore, at the end visual decision aids help to reduce funding the wrong innovation projects. Summing up, we test decision making approaches as the advice of an external consultant, visual decision aids and a combination of both approaches, to reduce escalation of commitment. In the following, we develop research hypotheses to analyze these questions.

3.1. The advice of a consultant

It is understandable that project managers would perceive the termination of a project as personal failure (Boulding et al., 1997; Schmidt & Calantone, 1998). “Individuals get emotionally involved in the project and are very reluctant to terminate it, even if there are many clear signals that the project is not going to be successful” (Balachandra, 1984, p. 92). The escalation of commitment phenomenon is usually seen in the initial personal involvement with the project (Staw 1976; Bazerman, Guiliano, & Appelman, 1984; Whyte, 1991). When negative feedback is received, decision makers who are responsible and involved in the initial decision are motivated to justify their earlier decision (Bobocel & Meyer, 1994; Staw et al., 1997). Especially, the emphasis of prior research on personal responsibility and escalation of commitment suggests that the advice of an external consultant may be an effective approach to prevent managers from the escalation trap (Kadous & Sedor, 2004; Perkmann & Walsh,

2008). We therefore analyze, if getting the advice of an external consultant helps to reduce escalation of commitment in a stage gate system.

Consultants do not have prior beliefs about a project, as they temporarily work for several firms in different industries and are (typically) not involved in the development process of an innovation project. Instead, consultants are used in identifying problems and work efficiently as they profit from a large knowledge base and their working experience (Sarvary, 1999). This experience allows the consultant to gather “best practices” from previous references as they mainly learn by working and are therefore experienced decision makers (Creplet, Dupouet, Kern, Mehmanpazir, & Munier, 2001). Especially, Keil & Robey (1999) discussed that de-escalation could be triggered by external consultants, as they managed existing resources better and make rational decisions. Therefore, we argue that the advice of a consultant regarding future costs and benefits of the innovation project will result in escalation-like behavior. Thus,

Hypothesis 1: Managers who use the advice of a consultant are less likely to continue funding a failing NPD project, and are less committed to a losing course of action than managers who do not use it.

3.2. Visual decision aids

This approach is to improve the quality and structure of project information, as visual decision aids can reduce commitment to a losing course of action (Bowen, 1987; Northcraft & Neale, 1986; Whyte, 1986). To structure data, companies often use tools for data presentation (Wainer & Velleman, 2001). Using visual decision aids help to turn financial spreadsheets into colorful graphs from existing databases, which makes data easily evaluable (Lurie & Mason, 2007) and allows to compare two and more elements (Blake, 1978). The plain visual decision aids are, the more likely it is for decision makers that they understand the information (DeSanctis, 1984). Visual decision aids are more easily presented to senior management than are large tables or detailed statistical analyses and are a good information

source for decision making. Visual decision aids help to understand complex relationships; it visualizes trends, makes forecasts and gives an overview of the business activities. It helps to enrich the information environment by structuring underlining uncertainties. Visual decision aids can have an impact on productivity (Ives, 1982). Limayem et al. (2004) showed that visual decision aids had a significant effect on all performance aspects, that is, system development processes as well as the product. Moreover, data presentation using appropriate visual decision aids can greatly improve data comprehension, which presumably helps reduce funding the wrong projects (Lurie & Mason, 2007; Wainer & Velleman, 2001). Thus,

Hypothesis 2: Managers who use visual decision aids are less likely to continue funding a failing NPD project, and are less committed to a losing course of action than managers who do not use it.

3.3. Mixed Approaches

Consultants extract a problem and then deliver the results of this analysis back to the client (Turner, 1982). Consultants act within missions where typical solutions fit forecasted projects. Their advices are based on given information, which they gain by firm reports, personal interviews and/or market research; however, this information can be error-prone (Thomke, 2006). For this account, they use specific tool boxes, contexts and graphical support, which helps them to formalize problems and solutions in a specific setting (Creplet et al., 2001). The consultant decides which visual decision aids they use in the decision making process and how they evaluate the given graphical information. Therefore, they make use of visual decision aids which are easy to pick up and which underline a given project failure or opportunity (Schein, 1969). However, visual decision aids can only be as effective as decision makers using them (Thomke, 2006). Therefore, the connection of both approaches is a useful and close to a reality setting, which reduces the weaknesses of the approach consulting and the approach visual decision aids. Mixing both approaches helps to underline sunk costs as well as reduces the personal involvement while funding an innovation project. Moreover, if

escalation of commitment is reduced when one approach is used, then one might conclude that using mixed approaches is most effective in reducing escalation of commitment. These mixed treatments are interesting to examine on theoretical as well as on practical grounds, because in firms we often find both approaches for managers who are responsible for project decisions. We assume that mixing both approaches for reducing escalation gains the strongest de-escalation effect. Thus,

Hypothesis 3: Managers who use mixed approaches are less likely to continue funding a failing NPD project, and are less committed to a losing course of action than managers who use just one approach.

3.4. Escalation of commitment during the new product development process

The level of commitment changes during the new product development process (Schmidt & Calantone, 2002). It is therefore important to examine approaches for reducing escalation of commitment at different stages. Garland (1990) found that the willingness to allocate money to a doubtful project increases absolutely and linearly as it moves closer to completion. Moreover, Simonson and Staw (1992) discuss de-escalation strategies for a losing course of action and found that decision makers should be evaluated along their decision process rather than just the single outcome. However, they offer no empirical support along the new product development process. Schmidt & Calantone (2002) complement these findings as they show that escalation of commitment is a more serious problem during NPD than after the product is commercialized. Following the argumentation about reducing escalation of commitment using the approach of a consultant, of visual decision aids, and the mixed approach, we can assume an effect over the stage gate system. Therefore, we hypothesize an effect of de-escalation like behavior while using the three approaches in a stage gate system. Thus,

Hypothesis 4 a: To reduce a losing course of action via the advice of a consultant will be weaker after the product is commercialized than before it is commercialized.

Hypothesis 4 b: To reduce a losing course of action via visual decision aids will be weaker after the product is commercialized than before it is commercialized.

Hypothesis 4 c: To reduce a losing course of action via mixed approaches will be weaker after the product is commercialized than before it is commercialized.

4. Research design and method

Following Boulding et al., (1997); Biyalogorsky et al., (2006) as well as Schmidt and Calantone (2002), we use an experimental design to test the research hypotheses. The four factors are a base/no decision aid condition (1), consultant information (2), visual decision aids (3), and a mixed condition (4). We analyze the decision behavior of R&D managers in a fictive stage gate process. The information provided for the R&D managers (e.g., overall financial implications of the innovation project / specific project information) are the same for all participants. We use an experimental design for several reasons. First, most risk to internal validity can be minimized through controlled experiments, which is essential to establish true causation (Cook & Campbell, 1979). Second, accurate testing of the research hypotheses would be virtually impossible using any other research method. For instance, retrospective research techniques such as surveys or personal interviews that center on actual decisions in past innovation projects might not yield truthful answers and suffer biases and errors due to inaccurate introspection of participants (Shepherd & Zacharakis, 1997) as managers probably do not really know why they made certain decisions in an earlier period. Last but not least, experiments are commonly used to study escalation of commitment behavior (e.g., Schmidt & Calantone, 2002; Montoya-Weiss & Calantone, 1994). Typically, in escalation of commitment studies, researchers ask participants to play the role of decision makers in a series of related investment choices.

Prior to performing this research experiment, we conducted ten in-depth interviews in multiple companies in Germany and pre-tested the study with several R&D managers in Germany and Ph.D.-students from our institution. This exploratory phase of the research

helped us to design the experimental treatment, layout, and procedure. The experiment also contains a post-experimental questionnaire, which we use to collect the demographic data of participants and their respective firms. The data collection instrument included a cover letter with general instructions about the task.

4.1. Sample and data collection

Our sample consists of R&D managers working in German firms, who are involved in the decision making processes of innovation projects. We identified the largest firms in different industries using the Hoppenstedt Database. We contacted 357 persons via telephone and/or email and asked for participation. If they agreed to participate, we explained the purpose of the study, and sent it to them. We reminded him or her via email and/or by telephone if they had not yet participated after some weeks. To boost response rate, as an incentive, every participant was promised a report with study results and was placed in a lottery with the chance to win an Ipod nano. We ended up with 137 participants representing a response rate of 38% (in terms of firms contacted).

We collected data on the characteristics of participants and the organization for which they work. The participants were on average 39 years old (standard deviation 10.2 years; maximum 60 years), 81% were male, 23% had a degree in engineering, 9% in natural science, 26% in business studies while the rest (42%) had a combination, e.g., background in business studies and engineering. 24% worked in the chemistry industry, 21% in the mechanical engineering industry, 13% in the electronic industry, 15% in the automotive industry, 10% in consumer goods and 17% worked in different industries. On average, the participants worked for their current firm for 9 years (standard deviation 7.5 years; maximum 32 years). 49% worked in the R&D department, 19% in innovation management, 17% in the marketing department and 15% in different departments. 39% were top-managers, 39% were middle managers and 22% were lower-level managers. We take these measures as a strong trend of

high managerial responsibility. These R&D managers were chosen to increase the external validity (generalization of your findings) of the experiment. The experimental participants were randomly assigned to one of the four conditions.

4.2. The case experimental task

Participants were asked to act as innovations managers in a fictitious firm. All participants were instructed that the goal was to create an optimal and profitable innovation project portfolio for the firm. In a stage gate system, participants made “go/stop- decisions” about the innovation project and answered questions about their level of commitment. They were also asked to justify their chosen option. At the end of the experiment, they answered questions about their own firm and replied manipulation check questions. If the participants initially chose not to launch the product, they were told they were finished with the job. If they chose to launch, the experiment continued with information about the project's performance after two years of being in the market.

At the completion of each stage, all participants received feedback on the financial aspects of the innovation project. This information was forecasted before product launch (Stages 1) and updated after commercialization (Stage 2). It is important to note that the financial feedback about the innovation project given to all R&D managers in all conditions was identically. Project performance data were simply presented in the base/no decision aid condition (1) and not interpreted. An overview of the experiment and specific project information is depicted in Figure 2.

Figure 2: AN OVERVIEW OF THE DECISION MAKING EXPERIMENT

Performance Feedback at each new product development gate

	Information first decision	Information second decision
Total sunk costs	1,6 million euro	4,6 million euro
New investment	2,17 million euro	250,000 euro
Market share	25%	19% (competitor 41%)
Probability of positive return	55%	25%
Expected return	1,8 million euro	minus
Market growth	5% (lower than competitor)	0% (competitor 7%)
Wastage in the project	0 euro	1,5 million euro

As shown in Figure 2², performance information of the project has a worsening trend. To make the decision process clear for all subjects, we assume that the success or failure of an innovation project rests on some key uncertainty variables. These financial key uncertainties were, e.g., market share, market growth, competitor response and probability of positive return (adapted from Schmidt & Calantone, 2002; Boulding et al., 1997). All R&D managers obtained negative performance feedback while escalation of commitment only occurs when project feedback is negative (Staw, 1976). For instance, in the particular example used in our research, there is a 45% chance that the innovation project does not gain a positive return. Moreover, the market share and market growth is lower than expected and lower than that of the primary competitor. We reported technological disadvantages. Participants were told that a production problem explains the lower than predicted market share after two years.

In the setting in which two decisions were made, the total time of participation was approximately 40 minutes. In the following, we describe the specific manipulations of the independent variables given to the R&D managers in each of the experimental conditions.

² Adapted by Schmidt and Calantone 2002, 1998 and Biyalogorski et al. 2006.

4.3. Manipulations of independent variables

The manipulations for the independent variables (wording of the experiment) is mapped in the appendix.

Consulting: The manipulated wording shall reduce the involvement with the decision making process. We introduced a top management consulting firm which is responsible for the given project data. The top management consulting firm gives the advice to stop the innovation project in both stages.

Visual decision aids: In the experiment, we use bubble diagrams and a color coded ranking list in order to structure the information for the R&D managers and to underline the given information used in the base condition. 44.4% of all businesses use diagrams and other graphics while analyzing innovation projects (Cooper, Edgett, & Kleinschmidt, 2002).

Mixed approaches: In this condition visual decision aids and consultant information exists. We test this condition, because in real life scenarios often both information sources appear in firms. Moreover, we expect the biggest trend in reducing commitment to a losing course of action.

Stages of the innovation process: The subjects' condition required R&D managers, who launched the innovation project to repeat the decision-making experiment at two stages (see Figure 1).

4.4. Measures of variables

The dependent variable of greatest interest in our analysis is the project “go/stop-decision” of R&D managers. Furthermore, we use the self-reported commitment to a failing innovation project as a construct to understand the escalation of commitment phenomenon in the decision process (Schmidt & Calantone, 2002; 1998). We further explore the retrospective justification treasures obtained from subjects after each decision (e.g., Boulding et al., 1997). These resources provide details about what information participants used and how they

interpreted the information. All four conditions have approximately the same cell size (number of participants), which makes the settings statistically comparable.³

5. Analyses and results

In the following, we analyze the go/stop-decision process and have a closer look at the development of the self reported commitment in the stage gate process. In the discussion section, we evaluate the retrospective justification of the participants within the experiment.

Go/stop-decision process: First of all, in Table 1, we summarize the results from the go/stop-decision process of each experimental condition. We asked the R&D managers to choose the accurate course of action for the innovation project. In the base/no decision aid condition (1), we did nothing to reduce the commitment to a losing course of action. We start by observing that 29 R&D managers in the base/no decision aid condition (1) recommended launching the product (91%) and 25 R&D managers (86%) invested again in the innovation project after it has been commercialized. This behavior is based on project information which shows that the project was losing money and the financial performance was lower than forecasted.

Table 1: SUMMARY OF EXPERIMENTAL RESULTS

Condition	N=137	First decision (first stage)				Second decision (second stage)				Total Stop		
		Go	No Go	% Stop	Sig. *	Go	No Go	% Stop	Sig.*	Total Stop N	% Total - stop	Sig.
Base/ no decision aid (1)	32	29	3	9%		25	4	14%		7	22%	
Consultant (2)	30	21	9	30%	0,041	16	5	24%	0,373	14	47%	0,040
Visual decision aids(3)	36	21	15	42%	0,002	16	5	24%	0,373	20	56%	0,004
Mixed approaches (4)	39	22	17	44%	0,001	14	8	36%	0,062	25	64%	0,000

*T-test were used for statistical analyses. Level in comparison to base condition/no decision aid condition.

³ Controlling for exact reading during the experiment, we asked the R&D managers at the end of the study, if they can remember the recommended investment amount. Just 9% were wrong and/or were not able to remember the investment amount.

Secondly, we pay attention to the manipulated conditions (2, 3 and 4). As indicate in Table 1, more R&D managers recommended stopping the innovation project in the three manipulated conditions. In the consultant condition (2), 30% of all R&D managers recommended stopping the innovation project before commercialization (9% vs. 30%, $p=0.041$). In the visual decision aids condition (3), 42% R&D managers stopped the innovation project (9% vs. 42%, $p=0.002$). In the mixed condition, we find the strongest trend in stopping the innovation project. 17 R&D managers (44%) stopped the innovation project before it is commercialized. We find that funding a losing NPD project is significantly reduced in this condition (9% vs. 44%, $p=0.001$). Managers who use visual decision aids and the advice of a consultant are less likely to continue funding a failing NPD project. We further find that managers who use mixed approaches are less likely to continue funding a failing NPD project than managers who use just one approach. Thus, we find statistical support for hypotheses 1, 2, and 3.

We additional analyze the results at the second stage. The decision making process in the manipulated conditions (2 and 3) are almost the same and not significantly different from the behavior observed in the base/no decision aid condition (1). In both conditions (2 and 3), 24% stopped the innovation project after they already invested again and after it has been commercialized. Most R&D managers seemed to get used to the extra information as consultant advice and graphic briefings. In the mixed condition, there still is the greatest trend in reducing the commitment to a losing course of action; 36% stop the innovation project after it has been commercialized; however, just at a weak-significant level ($p=0.062$) to the base/no decision aid condition (1). These findings support hypothesis 4a-c. We found that the effect to reduce a losing course of action via a consultant, via visual decision aids and via mixed approaches is weaker after a product is commercialized (second decision) than before it is commercialized (first decision).

Analyzing the total percentage of subjects pulling the product off the market, we find that an enriched decision environment and the support of a consultant reduce funding the wrong innovation project. Over the stage gate process, 47% of all R&D managers stopped the innovation project in the consultant condition (2). This is significantly different to the base/no decision aid condition (22% vs. 47%, $p=0.040$). The total stop in the visual decision aids condition (3) is 56% ($p=0.004$). In sum, 64% R&D managers stopped the innovation project in the mixed condition (4), which is significant different to the base/no decision aid condition (22% vs. 64%, $p=0.000$). These results underline our hypothesis.

Self-reported commitment: To strengthen and to underline our results (robustness check), we further analyzed self-reported commitment. Looking at the self-reported commitment to a failing innovation project; we report the means for the main effects during the development and after the launch in the appendix. The measurement items and reliabilities also appear in the appendix. Table 2 shows that managers in the manipulated conditions report a significant lower level of commitment to the failing innovation project, especially during the launch of the innovation project.

Table 2			
Effect Sizes and Significance: Pre- and Postcommercialization (ANOVA*)			
Dependent Variable	Main effect on condition	Effect Size	
		During development	After launch
Self reported-commitment	Base (1)		
	Consultant (2)	0.061	0.403
	Visual decision aids (3)	0.006	0.036
	Mixed approaches (4)	0.004	0.018
*Measured in comparison to base/no decision aid condition			

In the consultant condition (2), there is no significant effect ($F(1,61) = 3.642, p=0.061$ and $F(1,49) = 0.712, p=0.403$). In the visual decision aids condition (3), we find a significant reduction in the self-reported commitment during development ($F(1,67) = 8.204, p=0.006$) and after launch ($F(1,51) = 4.654, p=0.036$). Managers who use visual decision aids are less

committed to a losing course of action than managers who do not use it. R&D managers in the mixed condition (4) report the lowest commitment during development ($F(1.66) = 8.669$, $p=0.004$) and after launch ($F(1.50) = 5.980$, $p=0.018$). Managers who use mixed approaches are less committed to a losing course of action than managers who use just one approach.

6. Discussion

The results of this study advance the literature of new product development and escalation of commitment in several ways. Biyalogorsky et al., (2006) demonstrate that managers may continue to invest in a failing project as long as they can support the initial decision. This finding implies even if people being not involved in the start-up of an innovation project, they still may be influenced by biased feelings that can lead to an overly positive evaluation of the project's future. These results lead us to analyze, if people being not involved in the development of an innovation project can reduce funding the wrong innovation projects. We found that the advice of a consultant has positive effects on not funding the wrong projects. Therefore, it is important for decision makers to employ external consultant while doing an innovation project investment decision. We further test, if the use of visual decision aids help to reduce the escalation trap while doing a go/stop decision. Structuring data in an appropriate way and to underline sunk costs has a positive effect on the decision making process. Especially, visual decision aids are an important driver while reducing the escalation of commitment trap. Our study therefore indicates that the advice of an external consultant and visual decision aids reduce escalation tendencies and funding a failing innovation project. Results further underline that mixing both approaches is most effective in funding the wrong innovation project. We further contribute to repeated measurement investment decisions (Garland, Rogers, & Sandefur, 1990; Simonson & Staw, 1992) as we analyze the effects on commitment over time and how and when managers in organizations should use those approaches in a stage gate system to optimize the output of the

firm. We find that escalation of commitment can best be reduced before the product is commercialized. In other words, the use of extra information, as the advice of a consultant and visual decision aids have less impact on commitment during later stages. These findings on repeated decision making extends previous literature (Boulding et al., 1997) and contributes to research in a stage gate system (Schmidt & Calantone, 2002). Moreover, these findings conclude to previous results which showed that the absolute attention given to visual decision aids has a high impact; especially, during the early phases of decision making (Jarvenpaa, 1990).

Looking at the retrospective justification data of all R&D managers, we get an idea why particular decisions were made. Most subjects in the first condition offered a classical recommendation for pulling the innovation project as they focused on changes and risks of the innovation project. In the second game turn, participants reported being commitment to the project and they still would see changes to gain a positive return. Within the manipulated conditions the general comments about the innovation project were different. Most R&D managers in the consultant condition focused on financial project information (opportunity costs, market share and return on investment); however, some even said that they consequently decided against the advice of the consulting firm. Especially, they put the qualification of the consultant in question. These results could be an indicator, why the consultant condition was less significant than the visual decision aids condition. In this condition most R&D managers focused on strategic aspects and technological attractiveness of the innovation project. The visualization of information helped R&D managers to value the project indicators more easily.

Our study not only analyzes several approaches for reducing escalation of commitment in a stage gate system, it further gives advices how companies can optimize decision making processes within their organization. We achieve these results from a data set

with managers who are experienced decision makers within their company. One contribution to managerial practice is that the study underlines that escalation of commitment appears and can be reduced in a decision making process. Moreover, this study gives some guideline and approaches to reduce this phenomenon. Especially, we demonstrate that the escalation of commitment problem can best be reduced before an innovation project is commercialized, while managers should use visual decision aids and the advice of a consultant at the same time.

7. Limitations and future research

Several limitations in our research should be mentioned. In “reality” the consequences of specific decision processes are more harmful for R&D manager’s self-esteem and career opportunities. In an experiment, it is difficult to create anxiety and pressure being responsible for a one million euro project failure (Schmidt & Calantone, 1998). Another limitation is that the scenarios we use are relatively simple settings and do not include many of the complicated organizational details that might have an effect in real world project decision making. While we try to be as realistic as possible in creating the scenarios, we also want to control for extraneous sources of variance and provide only the essential information needed for the decision making process.

Furthermore, our study gives some ideas for interesting research avenues. We do not understand enough about the drivers and detailed influence factors of both approaches; therefore, future research is needed to identify additional advices for reducing the escalation of commitment phenomenon. Further research is needed to understand whether decision makers misinterpret given information or instead consciously ignore information to protect themselves from organizational sanctions.

8. Conclusion

As managers cope with new challenges while managing innovation projects in a stage gate system, there is a danger that escalation of commitment can lead to wastage of resources. Prior research on go/stop-decision making has suggested analyzing which approaches can reduce the escalation of commitment phenomenon. This study contributes by demonstrating that the advice of an external consultant and visual decision aids partly reduce the well known phenomenon in a stage gate system. It also illustrates that the effectiveness of such approaches is best if we mix it. Last but not least, we show that the escalation of commitment problem can better be reduced before an innovation project is commercialized. We have gained further insights into key aspects of innovation project management; especially, concerning which approaches decrease escalation of commitment while doing repeated investment decisions.

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Appendix

Appendix	Cronbachs Alpha	
<i>1. Measurement Items and Reliabilities</i>	Stage 1	Stage 2
	0,70	0,84
Psychological Commitment (Factor loading)		
I am committed to this new product.	0,769	0,878
I would feel guilty if I stopped funding this new product development project.	0,742	0,843
I will stick with this new product no matter what problems are encountered.	0,649	0,781
I feel sense of loyalty to this new product.	0,649	0,779
Go/Stop		
Given the opportunity, I would (a) stop this new development project or (b) continue this new development project.	n/a	n/a
Items measured on 1-to-7 scales anchored with "strongly agree" and "strongly disagree." Scales from Schmidt and Calatone (1998 and 2002).		

Cronbach's coefficient alpha results (0.70 during development and 0.84 after launch) indicated good inter-item reliability (Peter, 1979).

Dependent Variable	Main effect on condition	Stage 1	Stage 2
		During development	After launch
Self reported-commitment	Base (1)	3.7	3.5
	Consultant (2)	3.2	3.2
	Visual decision aids (3)	3	2.7
	Mixed approaches (4)	2.9	2.6

The Table shows, that the self-reported commitment in the mixed condition is the lowest (2.9 and 2.6) in comparison to the base/no decision aid condition (3.7 and 3.5). In the consulting condition, the means are the same in both stages (3.2) and in the tool condition the mean is reduced from 3 to 2.7. To understand these results in detail, we measure analysis of variance (ANOVA) for all manipulated conditions in comparison to the base/no decision aid condition across stages.

Wording Experiment⁴

Base Condition (first decision)

Please read carefully the firm situation. Afterwards, make your project decision and answer the following questions.

The outlined firm develops and produces technologically challenging products. Considerable industrial enterprises belong to the client base. For several years you have been the head of the innovation management department in this firm. You are responsible for the selection of prospective innovation projects. Your goal is to create an optimal and profitable innovation project portfolio for your firm. For one project you already invested a great amount of time and money. Especially, you already bought a new machine for 3 million euro. On that machine a new product shall be produced. Currently, the project is in the development phase and up to 70% ready for testing.

Your employees gave you further ratings and forecasts:

- Until completion of the innovation project you need to invest another 2.17 million euro.
- The probability of a positive return is 55%.
- If you would invest again: the overall costs of the innovation project would be higher than primarily planned (actual > balance due).
- The turnover of the innovation project is forecasted to be 24.5 million euro p.a. and the return is 1.8 million euro p.a.
- If you stop the innovation project and sell the new machine now you would realize a deficit of 1.6 million euro.
- The initial market share is anticipated with 25%.

⁴ We thank Eyal Biyalogorsky for sending us the wording of the experimental conditions from the paper „Stuck in the Past: Why Managers Persist with New Product Failure” Journal of Marketing (2006).

- Analysts of your firm predict that you will realize 5% market growth and your competitor will realize 7%.
- Your competitor has already started with the testing of a comparable product.
- At the moment you assume that the demand price of your product is higher than that of your competitor.
- The technology attractiveness (sum of all mechanical and commercial advantages) of your innovation project is expected to be higher in comparison to the competitor.

Now you need to evaluate the project.

- do you want to stop the innovation project or
- do you want to continue with the innovation project?

Base Condition (second decision)

Two years later: You decided to continue with the innovation project and you invested another 2.17 million euro. After testing the innovation project you have launched the product on the market. Below you find further information about the development of the innovation project. The information shall help you to do your last project decision.

You have not reached the planned market share of 25%. In fact, you reached 19% market share and your competitor reached 41% market share. Your market growth is 0% and your competitor reached 7% market growth in the current business year.

The primary reason you got less than the expected market share appears to be a result of the production process. While the product tested extremely well when produced in small batches, production in mass quantities appears to create a significant amount of heat. This reduced the quality and technology attractiveness of the product. However, on the long run the condition does appear to be correctable.

Your project earned just a volume of 8.1 million euro and therefore obtained wastage of 1.5 million euro.

Now you can ultimately evaluate the project.

- You can either stay in the market or invest further 250.000 euro. The probability to get a positive return on investment is 25%.
- Or you can sell the machine and realize wastage of 4.2 million euro.

(Text adapted from Biyalogorsky et al., 2006; Boulding et al., 1997; Schmidt & Calantone, 2002.)

Manipulations

Consultant condition (first decision)

The outlined firm develops and produces technologically challenging products. Considerable industrial enterprises belong to the client base.

Mr. Schmidt has been the head of the innovation management department in this firm in the last years. He has been responsible for the selection of prospective innovation projects. Due to health problems he has left the firm. You assumed his position in the firm. Mr. Schmidt's goal was to create an optimal and profitable innovation project portfolio for your firm. To reach that goal he enlisted a leading top management consulting firm. In this time he bought a new machine for 3 million euro. On that machine a new product shall be produced. Currently, the project is in the development phase and up to 70% ready for testing.

The top management consulting firm gave you further ratings and forecasts, in order to make your decision.

- Until completion of the innovation project you need to invest another 2.17 million euro.
- The probability of a positive return is 55%.
- If you would invest again: the overall costs of the innovation project would be higher than primarily planned (actual > balance due).

- The turnover of the innovation project is forecasted to be 24.5 million euro p.a. and the return is 1.8 million euro p.a.
- If you stop the innovation project and sell the new machine now you would realize a deficit of 1.6 million euro.
- The initial market share is anticipated with 25%.
- Analysts of your firm predict that you will realize 5% market growth and your competitor will realize 7%.
- Your competitor has already started with the testing of a comparable product.
- At the moment you assume that the demand price of your product is higher than that of your competitor.
- The technology attractiveness (sum of all mechanical and commercial advantages) of your innovation project is expected to be higher in comparison to the competitor.
- *The top management consulting firm recommends killing the innovation project.*

Consultant condition (second decision)

Two years later: You decided to continue with the innovation project and you invested another 2.17 million euro. After testing the innovation project you launched the product on the market. *This was accompanied by the support of the top management consulting firm.*

Bellow you find further information about the development of the innovation project. It shall help you to do your last project decision. *This information is conditioned by the top management consulting firm.*

You have not reached the planned market share of 25%. In fact, you reached 19% market share and your competitor reached 41% market share. Your market growth is 0% and your competitor reached 7% market growth in the current business year.

The primary reason you got less than the expected market share appears to be a result of the production process. While the product tested extremely well when produced in small batches,

production in mass quantities appears to create a significant amount of heat. This reduced the quality and technology attractiveness of the product. However, on the long run the condition does appear to be correctable.

Your project earned just a volume of 8.1 million euro and therefore obtained wastage of 1.5 million euro.

Anew the top management consulting firm recommends killing the project.

Now you can ultimately evaluate the project.

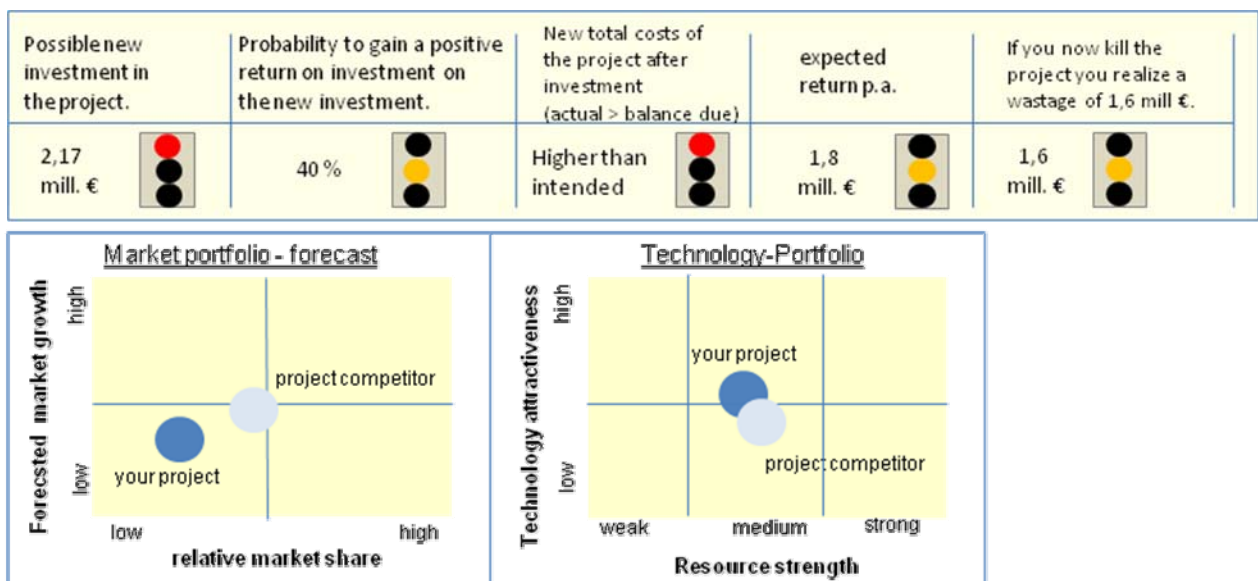
- You can either stay in the market or invest further 250.000 euro. The probability to get a positive return on investment is 25%.
- Or you can sell the machine and realize wastage of 4.2 million euro.

(Wording for being less responsible adapted by Wong, Yik, & Kwong, 2006; Whyte, 1993).

Visual decision aids condition (first decision)

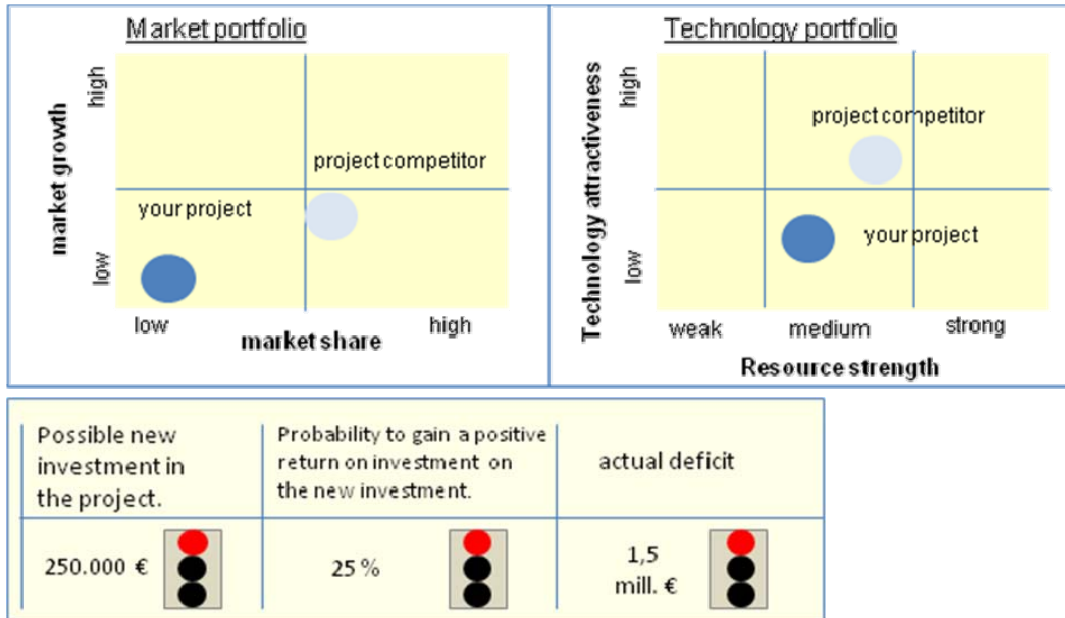
Participants got information from the Base condition and the following graphs:

Bellow you see all information in a graph. The color coded ranking list represents an internal evaluation of the chances and risks of the project.



Visual decision aids (second decision)

Participants got information from the Base condition and the following graphs:



Risk-reward bubble diagrams are a popular decision making approach in innovation project management (e.g., Cooper et al., 2002; Cooper et al., 1999).

Mixed condition (first decision)

Participants got information from the consultant condition and the visual decision aids condition.

Mixed condition (second decision)

Participants got information from the consultant condition and the visual decision aids condition.

Chapter D:

Disparities in innovation portfolio management decisions – An experimental analysis of R&D managers’ introspection

1. Abstract

This study investigates differences in innovation portfolio management decisions. We use a conjoint field experiment to collect data on 4032 decisions made by 126 R&D managers to test how project attributes influence the innovation portfolio. Especially, we find disparities in “self-reported” data and the “in use” of specific project information. We recognize that R&D manager’s value specific project attributes more and others less, as e.g., portfolio-fit which is an important characteristic in the context of innovation portfolio management. Managers should be conscious about these biases and disparities in their decision making behavior while they exploit innovation projects. Firms may use these findings in order to improve the decision making process and the overall innovation portfolio.

Keywords: differences in decision making processes, innovation portfolio management, experimental conjoint study.

2. Introduction

Project decision making in the context of innovation portfolio management is fundamental to successful new product development processes (Cooper, Edgett, & Kleinschmidt, 1999; Cooper, Edgett, & Kleinschmidt, 2001). Prior research about innovation portfolio management identified four major goals in order to improve the innovation portfolio management activities (Cooper et al., 1999). First of all, maximize the financial value of the firm's innovation portfolio. Secondly, find the right balance of innovation projects. Thirdly, the innovation projects need to be aligned with the corporate strategy. Fourthly, resources need to "fit" the number of active innovation projects. The four innovation portfolio management goals underline a good "portfolio-fit" of a specific innovation project (e.g., Cooper et al., 2001; Cooper et al., 1999). In particular, innovation portfolio management includes a dynamic decision process, whereby a firm's list of active new product projects is constantly updated and revised (Cooper et al., 2001; Griffin & Page, 1993; Graves, Ringuest, & Case, 2000; Roussel, Saad, & Erickson, 1991). In other words, innovation portfolio management focuses on project decisions while managers exploit innovation projects and push it in the overall portfolio. These decisions are a difficult task because many different strategic aspects need to be considered (Balachandra, 1984). Especially, innovation managers view each innovation project as an investment and attempt to apply decision techniques to pick the valuable investments for the innovation portfolio. Methods that are used for these project selection activities, as e.g. strategic buckets, have received some attention (Chao & Kavadias, 2008). Attributes as financial ratios of an innovation project are an established decision criteria as those list and rank projects based on indices and financial ratios (Cooper, 1999). Nevertheless, just focusing on these criteria's produce unbalanced portfolio results as these ignore other important strategic aspects (Cooper et al., 1999).

Managers sometimes cannot remember why they made specific project decisions. Therefore, the limitations in the research on decision making in the context of innovation

portfolio management include problems of retrospective. Former studies use questionnaire responses which include errors associated with self-reporting (e.g., Cooper *et al.*, 1999; Schmidt, Montoya-Weiss, & Massey, 2001). There is much to be learned about R&D managers' assessment decisions and the influence on the overall innovation portfolio (Hall & Hofer, 1993; Cooper *et al.*, 1999). Following experimental decision making studies (e.g., Shepherd 1999a,b; Shepherd and Zacharakis 1999; Patzelt, 2008; 1999), we use an experimental conjoint study to analyze disparities in the "in use" of innovation project attributes, (that is the innovation attributes which a manager considers while he or she is doing an exploitation decision) and "espoused" decision making (that is manager's self reported data). We further analyze the relative power and popularity of the innovation project criteria: portfolio-fit, market-fit, technological- and demand uncertainty, financial ratios and risk, as well as the influence factors team performance and champion. This study therefore addresses several interesting questions in the decision making process. Firstly, what decision criteria do R&D managers focus on while they exploit an innovation project? Secondly, which selection criteria are most important to R&D managers while they value the decision criteria independently? Thirdly, what are disparities in the in use and self reported data? How do they differ? Therefore, R&D manager's decision making processes in the context of innovation portfolio management are analyzed to determine their accuracy of their introspection. This research extends existing research on decision making processes. Especially, this study analyzes profitability-, uncertainty-, individual- and fit- considerations in the context of innovation portfolio management. The remainder of the paper is structured as follows. Next, we describe specific assessments of the innovation project selection process. We explain the experimental conjoint research method, sample frame, analyses, and results. As a final point, we discuss implications of our results.

3. Research on R&D manager's decision making criteria while exploiting an innovation project: The impact of particular project criteria

Social judgment theory is meant to be a universal framework for the study of human judgment and it focuses on the nature of the environment in which the decision is made (Strack, Martin, & Schwarz, 1988). Social judgment theory deals with the judgment of a stimulus and subsequent changes in attitude. An assumption of social judgment theory is that the individual's judgment of a message varies relative to personal ranges of recognition, refusal, or non-commitment (Strack et al., 1988). Uncertainty about correct behavior may also create individual introspection (Stahl & Zimmerer, 1984, Shepherd 1997b). Particularly, social judgment theorists suggest that espoused decision making processes may be a less than precise reflection of in use decision making processes (Priem & Harrison, 1994). Self-reporting usually overstates the decision criteria in reality used and understates the weighting of important criteria compared to more difficult decision making techniques (Stahl & Zimmerer, 1984). Therefore, the in use decision policies clarify a different variance in innovation portfolio decisions than do espoused decision making policies. Thus,

Hypothesis: R&D managers espoused decision making processes are different from their in use decision making processes while doing innovation portfolio management decisions.

In the following, we introduce and discuss specific innovation project attributes while managers exploit an innovation project. Especially, "fit"-considerations (portfolio-fit and market-fit), uncertainty considerations (technological- and demand uncertainty), individual considerations (reputation and champion) and profitability consideration (financial- and risk considerations) are introduced. Those are important influence factors of innovation portfolio management (Cooper, 1999; Cooper *et al.*, 1999) and are a multifunctional frame for the decision making process (e.g., Cooper et al., 2001; Griffin & Page, 1993; Graves et al., 2000).

Later on, the managers' disparities between espoused decision making policies and in use decision making policies are analyzed and a conclusion is drawn.

3.1. Fit-considerations

Researchers have suggested that firms implement some type of systematic portfolio management process (Cooper et al., 1999). This innovation portfolio management process is directed on "fit-considerations"; that is, focusing on managing the right innovation projects (Cooper et al., 1999). Especially, it is argued that through greater understanding of portfolio-fit and market-fit firms are more likely to develop new products that match their current expertise and resources (Cooper *et al.*, 1999; Griffin & Page, 1993).

Portfolio-fit: Portfolio management helps firms to realize an effective and efficient allocation of resources (Griffin & Page, 1993). Moreover, the idea of a profitable portfolio management system is to turn the business strategy into a dynamic set of innovation projects; the whole mix of projects need to be taken into consideration (Cooper et al., 2001). Therefore, portfolio-fit involves the value maximization and balance within the portfolio (Cooper, 1999). Portfolio-fit decisions are a connection between a firms' innovation activities and strategy. In other words, these decisions are not only based on individual project characteristics, they are also made in the context of the innovation portfolio management goals: (1) maximizing the value of the portfolio, (2) achieving the right balance and mix of projects, (3) linking the portfolio to the business strategy and (4) resources need to "fit" the number of active projects (Cooper et al., 1999).

Market-fit: Market-fit depends on conditions in the internal and external environment (Kohli & Jaworski, 1990). The duration of a temporary market-fit is important as it helps to determine whether innovation is needed or not (Feeny & Willcocks, 1998). With regard to market share and customer satisfaction, it further refers to the degree to which the new product adds a competitive advantage (Sarin & Mahajan, 2001). An explicit strategic competitive advantage of an innovation project can be gained when the project has a high

market-fit (Kohli & Jaworski, 1990). In this study, market-fit can be high or low for the innovation project.

3.2. Uncertainty considerations

Managers need to include uncertainty considerations in the innovation project exploitation process as they face uncertainty about technical success and customers' preferences. Especially, technological changes are constantly seen as sources of uncertainty for firms (Tushman & Nelson, 1990) and consumer preferences can be unstable and change quickly for new products (Wind & Mahajan, 1997).

Technological uncertainty: Technology and technological change are constantly seen as sources of uncertainty for firms (Tushman & Nelson, 1990). Firms often fail to develop winning new products when technology uncertainty is high (Pavitt, 1998). Moreover, technological uncertainty exists when it is not obvious which technology will emerge to lead in the market (Tushman & Rosenkopf, 1992). Firms must decide which technology to embed in their products to realize future market requirements (Krishnan & Bhattacharya, 2002). For this reason, technology uncertainty increases the difficulty for managers to analyze the character of technological changes and their implications for customer needs (Tushman & Nelson, 1990). Technological uncertainty of the innovation project can be high or low in this experimental conjoint study.

Demand uncertainty: Demand uncertainty refers to the perceived speed of change and unpredictability of customers' product preferences and demands as well as the emergence of new customer segments (Jaworski & Kohli, 1993). It is generally associated with the instability of consumer expectations (Zhou, Yim, & Tse, 2005). Nevertheless, in business, consumer preferences are unstable and change quickly. The identification of consumers' changing needs becomes increasingly difficult which increases demand uncertainty (Wind & Mahajan, 1997). In this study, demand uncertainty implies an existing customers' option or no customer demand.

3.3. Individual consideration

Individual considerations have an impact on the exploitation decision (Cooper *et al.*, 1999; Shane, 1994). Especially, studies demonstrated that people form evaluations and a reputation about people using information acquired from personal knowledge, observation, or third parties (Mehra, Dixon, Brass, & Robertson, 2006). A third party can be a champion, who uses informal methods to support precious innovation projects (Anderson & Shirako, 2008).

Reputation: Theoretical attention has been given to understand how individuals build reputation (Kreps & Wilson, 1982). Reputation is a source of rent and profit, hard to duplicate and a measure of effectiveness (Dollinger, Golden, & Saxton, 1997). Individual's reputation is defined as the attributes that are recognized by other people (Raub & Weesie, 1990). It is a shared opinion about the characteristics of an individual person (Anderson & Shirako, 2008). To have a reputation is to be known for something (Emler, 1990) and/or to have a competence in a specific topic (Kilduff & Krackhardt, 1994). A positive good reputation brings status and acceptance within an organization and often means he or she is known to be trustworthy and a good performer. A negative reputation can bring individual punishment and isolation (Flynn, 2003; Hardy & Van Vugt, 2006). This underlines that a reputation can incentivize individuals to behave more cooperatively. Individuals and teams are vulnerable to anything that damages their reputation as they get rewarded or punished for their decisions. To have a positive or negative reputation in this setting means that the project leader and this team have (un-) successfully managed innovation projects in the past.

Champion: Fundamental to the conception of a champion is the idea that he or she influences others to support specific innovation projects (e.g., Chakrabarti, 1974; Schon, 1963). A champion is someone with significant power and status within a firm, who informally emerge in an organization and who takes a personal risk in business development (Chakrabarti, 1974; Howell, Shea, & Higgins, 2005; Shane, 1994). More precisely, the PDMA Handbook of Product Development defines a champion as (1996, p. 519) "a person

who takes an inordinate interest in seeing that a particular process or product is fully developed and marketed. The role varies from situations calling for little more than stimulating awareness of the opportunity to extreme cases where the champion tries to force a project past the strongly entrenched internal resistance of firm policy or that of objecting parties.” He or she promotes innovation projects through critical stages. Studies underline that just a marginal group of firm members turn out to be a champion (Howell & Higgins, 1990). In the literature, we find three major roles: the technical champion, the executive champion, and the project champion (e.g., Hauschildt & Kirchmann, 2001). In this research, we use the term project champion, as he or she personally supports or not supports the innovation project.

3.4. Profitability consideration

Many firms use profitability considerations for portfolio management and project exploitation decisions (Cooper, Edgett, & Kleinschmidt, 1998; Cooper *et al.*, 1999). Those decisions include financial methods and risk aspects which are established and popular decision criteria (Cooper *et al.*, 1998). Especially, profitability considerations include diverse indices as e.g., the return on investment, the net present value and risk indices (Cooper *et al.*, 1998, Cooper *et al.*, 1999).

Financial ratios: Financial ratios are established measures of the financial situation of innovation projects and portfolio management (Cooper *et al.*, 1998). Financial ratios are indices which express the relationship between two or more items appearing on a balance-sheet. Those help innovation managers to rank projects against each other. Moreover, the estimated profits from the innovation project are integrated into the firm’s financial forecast and plans. 77.3% of businesses use financial methods to rank and select innovation projects (Cooper *et al.*, 1999). In this decision making experiment, financial ratios of the innovation project can be positive or below average.

General project risk: Theoretical formulations of decision-related risk (e.g., Kahneman & Tversky, 1979, Camerer & Weber, 1992) suggest that positive expected returns bring different decision making behavior than do outcome sets with negative expected values. Prospect theory identifies that situations, which decision makers label as positive, lead to risk-averse behavior, whereas situations which decision makers label as negative lead to risk-seeking behavior (Kahneman & Tversky, 1979). The attitude towards risk is a psychological character of individuals to show varying degrees of risk-taking or risk avoidance behavior (Levitt & March, 1988). In this study, risk includes a variance examination with upside and downside outcomes of the innovation project. We use the term as the probability of an expected positive or negative value of the innovation project.

4. Methods

4.1. Sample and data collection

The Hoppensted Database was used to identify potential firms and participants by classifying the largest firms in different branches. We use larger firms as those have a high R&D power (Hashai & Almor, 2008). R&D managers were the target group of this study. We contacted 284 persons via telephone and asked for participation. If they agreed to participate, we explained the purpose of the study, and sent it to them. We ended up with 126 participants representing a response rate of 44%. The study also contained a post-experimental questionnaire, which we used to collect the demographic data of participants and their respective firms. The participants were on average 39 years old (standard deviation 10.08), 86.7% were male, 41.3% had a degree in engineering, 22.2% in natural science, 21.4% in business studies while the rest (15.1%) had a combination, e.g. background in business studies and engineering. 29.6% worked in the chemistry industry, 27.8% in the mechanical engineering industry, 17.5% in the electronic industry and 25.1% worked in different industries. 53% worked in the R&D department of the firm, 11.9 % for the innovation management department, 10.3% in the strategy department, 10.3% in the marketing

department and 14.3% in different departments. On average, the participants have worked for their current firm for 10 (standard deviation 13.15) years.

4.2. Conjoint Analyses and Design

This study uses conjoint analysis, a technique that requires respondents to make a series of judgments based on a set of attributes (Shepherd & Zacharakis, 1997). Conjoint analysis is a strong tool for decision modeling research providing significant and structured insights into decision making criteria. Conjoint analysis is particularly appropriate for this study because as a real time method it overcomes many of the potential errors associated with post-hoc methods. We used a metric conjoint analysis to collect data on the manager's likelihood to exploit an innovation project. Conjoint studies require decision makers to make assessments based on a number of attributes representing the research variables. These attributes are described by two levels (i.e., positive or negative). Conjoint methodology draws on the assumption that decisions of individuals can be decomposed into their underlying structure (Green, Krieger, & Wind, 2001).

Profiles of our experimental design consist of eight attributes, each of which is represented by two levels, yielding $2^8=256$ profiles; assessing 256 profiles would be a time-consuming and not easily manageable task for the respondent. In order to address this problem, we employ an orthogonal factorial design to reduce the number of attribute combinations to 16 and collected judgments of 16 different attribute combinations from each participant (Hahn & Shapiro, 1966). Full replication of all 16 attributes combinations of our experimental design resulted in 32 profiles, we randomly assigned the 32 profiles as well as the profiles resulting in several versions of the experiment. In order to test for possible order effects, we compared the mean score across the different versions and found there to be no significant difference. In the conjoint experiment, participants are first provided with a description of the decision situation. Afterwards, they are presented with decision profiles each representing a specific innovation project. The data collection instrument included a

cover letter with instructions which guided them through the experiment and one page defining all attributes and levels contained in the study. We included a practice profile as first evaluation task in order to familiarize the R&D managers with the decision situation before starting the experiment. The practice profile is not included in the statistical analysis.

4.3. Measures

In this study, R&D managers evaluate a series of hypothetical conjoint profiles (innovation projects) which are described by eight attributes, each with two levels. The judgments of the decision makers represent the *dependent variable*, whereas the attributes describing the decision scenario constitute the *independent variables*. The dependent variable of our study is the manager's likelihood to exploit an innovation project. We asked managers to judge the attractiveness of exploiting a specific innovation project into the innovation portfolio on a seven-point Likert-type scale from "1= very unlikely" to "7= very likely". (We use this measure for the in use decision process). The decision attributes in this experiment were presented with eight attributes describing specific characteristics of an innovation project. Participants' introspection of the attributes of the innovation project decision was achieved by comparing their conjoint generated importance weights with their self-explicated importance weights measured in the questionnaire after the experiment on a seven-point Likert-type scale. (See appendix).

In figure 1, you find summarized a description on the attributes of the experimental conjoint study. The attributes of this study were theoretically justified and pilot tested. Moreover, we conducted ten in-depth interviews with R&D managers from different branches to verify the importance of the specific attributes of the experiment. The interview partners underlined the importance of the chosen project characteristics while making a project exploitation decision.

Figure 1: Attributes of the experimental conjoint study

Attributes conjoint experiment	Characteristic	Definition
1 Portfolio-fit	high	The innovation project fits well into the overall innovation portfolio.
	low	The innovation project partly fits into the innovation portfolio.
2 Market-fit	high	The innovation project has an explicit strategic competitive advantage.
	low	The innovation project has not a strategic competitive advantage.
3 Technological uncertainty	low	The technology of the innovation project already exists in the company.
	high	The technology of the innovation project is new for the company.
4 Demand uncertainty	low	There is a specific customer's option.
	high	There are still no customers for the project
5 Reputation	positive	The project leader and his team have managed successful innovation projects in the past.
	negative	The project leader and his team have managed unsuccessful innovation projects in the past.
6 Champion	existing	The innovation project is supported by an active champion in the top management.
	non existing	The innovation project is not supported by an active champion in the top management.
7 Financial ratios	positive	The financial ratios of the innovation project are positive.
	negative	The financial ratios of the innovation project are below average.
8 Risk	low	The risk of the project is estimated as low.
	high	The risk of the innovation project is estimated to be high.

- 1) *Portfolio-fit*: describes the level of adaption of the innovation project into the innovation portfolio of a firm and ranges from a well fit to partly fit.
- 2) *Market-fit*: means that the innovation project provides, in comparison to other products on the market, either an explicit strategic competitive advantage for the firm, or has a low value.
- 3) *Technological uncertainty*: means that the access of the technological knowledge exists already in the firm or is totally new for the described innovation project.
- 4) *Demand uncertainty*: stands for an existing customers' option or for no customer demand before the innovation project should be added into the portfolio.
- 5) Positive (versus negative) *reputation*, meaning that the project leader and his team have (un-) successfully managed innovation projects in the past.
- 6) The support of an active top-management member, by name *champion*, who can support the innovation project or respectively not support it.
- 7) *Financial ratios*: range from ranking or selecting projects based on traditional net present value through various financial indices. They can be very positive or below average.
- 8) *Risk*: which is the probability of an expected positive or negative value. Risk can be estimated as low or as high.

4.4. Analytical procedure

This study uses conjoint analysis to determine if specific project attributes are actually those used to exploit an innovation portfolio. Our study yielded 126 participants who exploited 4032 innovation projects. Analysis of variance (ANOVA) and regressions are the statistical method used to decompose the project decisions, because regression decomposes an assessment into its underlying structure (the independent variables and their corresponding beta coefficients) (also see Shepherd 1997b). The conjoint method allows analysis at both the individual and aggregate subject level, which improves the analytical ability of the research (Moore, 1980). To identify the significant attributes at the aggregate level, the regression coefficient for each attribute are averaged across individuals (Vancouver & Morrison, 1995).

Furthermore, z-statistic aggregates the t-statistics achieved from the individual-subject analysis for a project attribute to identify whether a particular project attribute is significantly used by the R&D manager (Dechow, Huson, & Sloan, 1994). To identify the attributes of exploiting an innovation project that are statistically significant, an individual-subject ANOVA is performed on the project attributes of each R&D manager. It is unlikely that the project attributes will be of equal weight. Therefore, statistical significance at the individual level was supplemented with a measure of relative importance. Following other studies (e.g. Shepherd 1997b; Patzelt 2008) Hays' (1973) omega squared was used to evaluate the relative importance of the eight project attributes, which is a measure to explain variance.

Furthermore, since conjoint analysis reflects a more legal assessment of a respondent's in use decision-making policy than analysis dependent upon R&D managers espoused policy, the following results report the relationship found between the participants' importance measures based on the conjoint analysis and their self-reported attributions of importance. The relative importance of each in use attribute was calculated as a percentage of attribute importance (each attributes' omega squared value) over the total weight of all eight attributes. The same calculation of relative importance was used for the self-reported data.

5. Results

In metric conjoint experiments, the issue of reliability of the assessments of participants is accounted for by replication of profiles and test-retest checks (Shepherd & Zacharakis, 1997). To demonstrate that the conjoint task was performed consistently by the participants, we analyzed mean test-retest correlation, which are .72 and therefore similar to other studies (Shepherd, 1999a; .69). Similar to previous work, the mean R^2 of the individual models was .78 (Shepherd, 1999a; .78). Table 1 displays the aggregated regression coefficients for each factor, its corresponding z-score, and omega squared value. At the aggregate level of analysis, the z-scores indicate that: Financial ratios, market-fit, demand uncertainty, and risk have a significant positive effect while managers exploit an innovation project. On average, the most important criteria for innovation managers while exploiting innovation projects are financial ratios ($w = 0.148$), market-fit ($w = 0.131$), demand uncertainty ($w = 0.132$) and risk ($w = 0.077$) as these have a significant z-score. Innovation managers pay less attention on the attributes reputation ($w = 0.062$), champion ($w = 0.059$), portfolio-fit ($w = 0.046$) and technological uncertainty ($w = 0.043$).

Table 1: Significance and importance of decision criteria

	β coefficient	z-score	omega squared
Portfolio-fit	0.537	19.59	0.046
Market-fit	1.117	38.67**	0.131
Technological uncertainty	0.606	21.52	0.043
Demand uncertainty	1.108	38.24**	0.132
Reputation	0.612	21.71	0.062
Champion	0.657	23.13	0.059
Financial ratios	1.134	39.14*	0.148
Risk	0.851	29.70*	0.077

** $p < 0.05$; * $p < 0.10$

Since conjoint analysis is thought to be a more valid assessment of a respondent's in use decision-making policy than analysis dependent upon innovation managers espoused policy, the following results report the relationship found between the participants' importance measures based on the conjoint analysis and their self-reported attributions of importance (Shepherd, 1999b). The relative importance of each in use attribute was calculated as a percentage of attribute importance (each attribute's omega squared value) over the total importance of all eight attributes. The same calculation of relative importance was used for espoused attributes. Differences between conjoint and self-explicated models indicate that innovation managers have limited insight into their own decision making processes. Table 2 shows the comparison of the attributes' relative importance and underlines disparities in the decision making process.

Table 2:
Comparison of attributes' relative importance

Attributes	Conjoint method (percent)	Self Explicated Method (percent)	Disparities (percent)
Financial ratios	21.2	13.9	+ 7.3
Demand uncertainty	18.9	15.0	+ 3.9
Market-fit	18.8	15.5	+ 3.3
Risk	18.8	11.5	+ 7.3
Reputation	8.9	10.2	- 1.2
Champion	8.4	11.0	- 2.6
Portfolio-fit	6.6	11.0	- 4.3
Technological uncertainty	6.1	12.0	- 5.9

In the in use method (measured in the conjoint experiment), R&D managers focus on four key attributes while they exploited an innovation project: financial ratios (21.2%), demand uncertainty (18.9%), market-fit (18.8%) and risk (18.8%). To a less extent, R&D managers look for the attributes: reputation (8.9%), champion (8.4%), portfolio-fit (6.6%) and technological uncertainty (6.1%). In the self-explicated method, the participants evaluate the individual project attributes with equal variance (reputation = 10.2 lowest score and market-fit = 15.5 highest score). The attributes financial ratios, demand uncertainty, market-fit and risk

clarify a positive disparity between the in use and self-explicated method. The attributes champion, reputation, technological uncertainty and portfolio-fit clarify a negative disparity between the in use and the self-explicated method. We see the biggest positive variance in the attributes financial ratios (+7.3) and risk (+7.3); furthermore, the biggest negative variance in the attributes technological uncertainty (-5.9) and portfolio-fit (-4.3). Therefore, the hypothesis is supported as R&D managers espoused decision making processes are different from their in use decision making processes.

6. Discussion and Contribution

The purpose of this article was to analyze fit-considerations, uncertainty considerations, individual considerations and profitability considerations while R&D managers exploit an innovation project. By drawing on an experimental conjoint study, this article further provides insides of the disparities in the in use and self reported data in the decision making process. Firstly, we analyzed fit-considerations as work by Cooper et al. (2002) indicated that only 21.2% of firms report having a well-executed portfolio management and that many firms rate their portfolio management as very weak. Interestingly, we found that R&D managers just consider market-fit criteria; however, forget about the four goals of an optimal innovation portfolio management. R&D managers ignore the important portfolio-fit consideration while they exploit an innovation project. One explanation might be that managers are not familiar enough with the strategic aspects of innovation portfolio management and therefore focus more on financial methods although top performing firms focus less on financial methods than do poor performing firms (Cooper *et al.*, 1999). Our study, as a result, indicates that R&D managers focus on established project criteria and are so far not versant with the influence of portfolio-fit. We suspect that R&D managers have limited knowledge about the topic innovation portfolio management and its interrelated success factors. Increased knowledge about the four goals of innovation portfolio management might improve portfolio performance as it helps to find the best projects for the

overall portfolio. The findings about the uncertainty considerations underline that R&D managers focus on uncertainty aspects, especially they focus on demand uncertainty while exploiting an innovation project. Moreover, technological uncertainty considerations are a barrier for disruptive technologies (Bower & Christensen, 1995) and should be included in the decision making process. Especially, individual considerations (the influence of reputation and champion) were underrepresented elements in the decision making process. R&D managers should expand criteria while making exploitation decisions, as just looking for profitability considerations brings an unbalanced and low-performing innovation portfolio (Libertore, 1987; Cooper et al., 1999). They should use the power and influence of a champion to break barriers within the company to select the best innovation projects for the portfolio (Chakrabarti, 1974; Schon, 1963). We, moreover, found that R&D managers focus on profitability considerations while they exploit an innovation project. Especially, they like to exploit innovation projects based on good financial indices and positive risk criteria, as those are popular decision criteria (Chao & Kavadias, 2008). Summing up, our results underlined that R&D managers just focus on four established project criteria: financial ratios, demand uncertainty, market-fit, and risk.

Furthermore, our study results extend the literature on innovation portfolio management (Cooper, 1999; Cooper *et al.*, 1999; Cooper *et al.*, 2001), which partly explains how an optimal innovation portfolio management should look like. However, those studies use retrospective methods (questionnaires) which suffer biases and errors. This experimental conjoint study analyzes innovation portfolio management decisions while the decision is made. Of particular interest of our study are the findings regarding potential disparities in the in use and espoused decision making criteria. We found positive and negative disparities between all project criteria. This is an indicator that managers have limited insights into their own introspection. This study will therefore increase knowledge of the gap between R&D managers in use and espoused decision making policies. Moreover, these findings help

managers to better understand their own decision making policies. This finally creates a profitable and balanced innovation portfolio.

The research technique experimental conjoint study itself has some limitations. In the framework of this field experiment, we were limited to the number of project attributes that we could manipulate and test. Though, there are facts that even in the most artificial situations conjoint analyses reflect the decision policies actually used by decision makers (Hammond & Adelman, 1976). Moreover, “real world scenarios” might be more multifaceted. However, studies underline that conjoint analyses replicate real-world judgments of individuals (Hammond & Adelman, 1976) and when pilot-tested the profiles demonstrated face validity. We hope that future research continues to work on an understanding and improvement of the decision making process of innovation portfolio management. As innovation portfolio management decisions are a complex process, as projects need to be prioritized against each other, future research may analyze this dynamic decision process. Therefore, more theoretical and experimental work is required.

7. Conclusion

In conclusion, our study suggests that decision makers’ likelihood to exploit an innovation project is influenced by financial ratios, market-fit, demand uncertainty and risk; however, managers value the influence of reputation, champion, portfolio-fit and technological uncertainty less. Drawing on field experiment data, we further showed that the in use decision making process differs from managers espoused decision making processes. Especially, we found positive and negative disparities on all innovation project criteria. Managers should be aware about these biases and disparities in their decision making behavior while they exploit innovation projects. Our findings help decision makers to draw more accurate decisions by better understanding their own decision strategies. We further extend the literature on decision making and innovation portfolio management. We hope

scholarly work continues to investigate decision making processes in the dynamic innovation portfolio management process.

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Appendix

Attributes self-reported data

Attributes self-reported data	seven-point Likert-type scale from “1= not important ” to “7= very important”.
1 Portfolio-fit	How important is the mentioned project attribute for you while you exploit an innovation project into the overall innovation portfolio?
2 Market-fit	How important is the mentioned project attribute for you while you exploit an innovation project into the overall innovation portfolio?
3 Technological uncertainty	How important is the mentioned project attribute for you while you exploit an innovation project into the overall innovation portfolio?
4 Demand uncertainty	How important is the mentioned project attribute for you while you exploit an innovation project into the overall innovation portfolio?
5 Reputation	How important is the mentioned project attribute for you while you exploit an innovation project into the overall innovation portfolio?
6 Champion	How important is the mentioned project attribute for you while you exploit an innovation project into the overall innovation portfolio?
7 Financial ratios	How important is the mentioned project attribute for you while you exploit an innovation project into the overall innovation portfolio?
8 Risk	How important is the mentioned project attribute for you while you exploit an innovation project into the overall innovation portfolio?

Chapter E: Summary, implications and outlook

1. Summary of major results

Prior innovation research has focused on the new product development process, which refers to activities taking a new product project from idea to launch (Cooper, 2008). By contrast, innovation portfolio management as the complementary activity of identifying and managing the portfolio of “right” innovation projects has been fairly unobserved (Cooper, Edgett, & Kleinschmidt, 1999). As mentioned before, picking the right innovation projects includes a permanent update and revision of projects (Cooper, Edgett, & Kleinschmidt, 2002). Referring back to chapter A, this dissertation analyzed these decision procedures; especially, the project go/stop-decision processes. Founded on a theoretical basis and ten pre-study interviews conducted with R&D managers in various industries in Germany 2008 about decision making in the context of innovation portfolio management, I developed two decision making experiments and tested a distinct set of hypotheses by two large-scale experimental studies. Beside descriptive statistics, SPSS/PASW Statistics (chapter B, C, and D), HLM 6 (chapter B) and STATA 11 (chapter D) were used for further advanced statistical analyzes. Moreover, the studies extended the literature on product innovation, portfolio strategy and decision making processes in psychology and marketing. This dissertation especially categorized, analyzed and helped to optimize the decision making processes and the decision behavior in the context of innovation portfolio management. Moreover, I evaluated which innovation project attributes have the strongest impact on the innovation portfolio management decision; how decision makers can improve the decision process and how they can reduce potential decision making problems. In the following, I summarize the empirical results from chapters B, C, and D. The chapters B and D are based on the data and results of the experimental conjoint study, whereas chapter C is founded by the data of the psychological decision making experiment. In the following, I sum up those results. These

findings form the basis for the implications for future research journeys and recommendations for managerial practice.

1.1 Summary experimental conjoint study

I used a conjoint field experiment (Chapter B and D) to collect data on 4032 decisions made by 126 R&D managers in Germany. I tested how project attributes and characteristics of decision makers influence the innovation portfolio (Chapter B). Moreover, I analyzed disparities in the “in use” of these project attributes compared with self reported data (Chapter D). The specific innovation projects characteristics while exploiting an innovation project were: portfolio-fit, market-fit, technological uncertainty, demand uncertainty, financial ratios, risk, reputation and champion. For further details see appendix chapter B.

I found that over and above projected financial risk and reward, decision makers considered other aspects and also considered the project in the context of their current innovation portfolio when making exploitation decisions. Especially, decision maker’s exploited an innovation project that is high in portfolio-fit and high in market-fit. In addition, managers focused on innovation projects that are low in technological uncertainty and low in demand uncertainty. The experimental conjoint study showed project experience has an impact on the decision behavior (Agor, 1986; Giunipero, Dawley, & Anthony, 1999). I found that significant decision differences exist at higher levels of project experience; furthermore, results demonstrated that project experience makes little difference to senior level managers, but significant difference to lower level managers. I illustrated that senior level managers and lower level managers’ focus on fit aspects; however, they did so with different intensity. I further found that lower level managers with more experience concentrate more on strategic fit aspects and less on uncertainty considerations.

Chapter D analyzed the specific impact of project attributes while exploiting an innovation project. In this context, I found disparities in the “in use” and espoused decision

making process. I illustrated that managers significantly exploited innovation projects, which have the following attributes low demand uncertainty, high market fit, positive financial ratios and low risk. Comparing these “in use” results with self reported data, I exemplified positive and negative disparities on key project characteristics. By way of example, managers focus less on key innovation portfolio management characteristics as portfolio-fit, instead on traditional financial ratios which can lead to an unbalanced innovation portfolio.

1.2. Summary experiment

In the experiment, I analyzed how decision makers relieve themselves from the escalation of commitment trap, that is, “good money chasing bad” (Simonson & Staw, 1992). Especially, I analyzed the effects of an advice of a consultant and visual decision aids to help decision makers selecting innovation projects in a stage gate system (Cooper et al., 1999). Study results illustrated that visual decision aids and the advice of a consultant reduce to continue funding a losing course of action. Particularly, graphical decision aids are a significant driver while reducing the escalation of commitment trap in a stage gate system. Moreover, mixing both approaches (the advice of an external consultant and visual decision aids) is the best for reducing the well know phenomenon. The study further gave advices to repeated measurement investment decisions (Garland, Rogers, & Sandefur, 1990; Simonson & Staw, 1992), especially, how and when managers in organizations should use those approaches in a stage gate system to reduce funding the wrong innovation projects. I found, that reducing escalation of commitment can best be reduced before the product is commercialized. Generally speaking, the advice of a consultant and graphical decision aids, have less impact on escalation of commitment during later stages in the innovation process.

2. Implications

2.1. Academic implications

Apart from structuring the topic of innovation portfolio management, the paper series has provided an overview of the go/stop-decision processes, which were analyzed by two experimental studies. With reference to the last chapters (B, C, and D), the following discussion of my academic implications are divided into a conceptual part and a methodological section.

From a conceptual perspective, this dissertation makes numerous important contributions to the *new product development* and *innovation portfolio management literature* by exploring and improving the decision making process of innovation projects against the background of innovation portfolio management.

Firms set important conditions for innovation projects, particularly in the early phases of the new product development process. For that reason, innovation portfolio management can be considered as an additional process along the stage gate process. This dissertation contributes therefore to the literature of *new product development* (e.g., Cooper, 2008; Griffin, 1997) and *innovation portfolio management* (e.g., Cooper, Edgett, & Kleinschmidt, 2001; Griffin & Page, 1993; Graves, Ringuest, & Case, 2000; Roussel, Saad, & Erickson, 1991) as the specific relationship between the innovation portfolio management process and the well-known new product development process is analyzed (Cooper, 2008; Cooper *et al.*, 2001; Cooper *et al.*, 1999). Furthermore, existing research gaps were identified focusing on the improvement in the decision making process at the intersection of innovation portfolio management and new product development. Most important, I identified influence factors in the decision process which help to improve the decision process itself and the performance of the overall innovation portfolio. As such, this dissertation is an important basis for further conceptual, experimental and empirical research about innovation portfolio management decisions.

In the field of *decision making studies* focusing on the *escalation of commitment* phenomenon, researchers have called for further research as “the mechanism of escalation of commitment remains relatively unknown and under researched” (Schmidt & Calantone 2002, p. 105). As mentioned in the previous chapters, failures and negative feedback often do not minimize commitment, nor do they lead to a different action plan (Staw & Fox, 1977). My dissertation contributes by identifying which approaches reduce escalation tendencies (e.g.; Boulding, Morgan, & Staelin, 1997; Keil & Robey, 1999; McNamara, Moon, & Bromiley, 2002; Bolton, 2003; Staw & Ross, 1987) by analyzing the direct advice of a consultant in the decision making process and by testing visual decision aids in a stage gate system. By doing so, I followed the suggestion by Biyalogorski et al., (2006) who recommended “change the organizational structure such that continue/stop decisions are made by someone with no prior beliefs about the project” to reduce the escalation of commitment phenomenon. In addition, the second approach, which I tested to reduce the escalation of commitment phenomenon, is based on the sunk cost effect (Arkes & Blumer, 1985; Staw, 1976). Indirect hints mapped by visual decision aids may help to underline the sunk cost effect of an unprofitable investment decision. Therefore, I tested, if visual decision aids help to improve the decision making process and reduce the escalation of commitment phenomenon. I further contributed to (repeated) decision making investments in the stage gate system (Garland et al., 1990; Simonson & Staw, 1992; Cooper, 2008). Especially, results underline that the escalation of commitment trap can best be reduced before the product is commercialized. These findings on repeated decision making expanded previous literature (Boulding et al., 1997; Schmidt & Calantone, 2002).

The implications for research from *a methodological perspective* concern the use of the research design (*psychological*) *experiments* and *experimental conjoint analysis*.

Experimental research is an area that utilizes scientific methods. Experimental researchers work in a wide variety of settings including universities, research centers, and private businesses. Experiments are used to establish cause and effect plus to determine the effects of a treatment. In an experiment, participants are randomly assigned to the research groups. Generally, one group is the control group (e.g., base condition), while the other groups are the experimental group and receive treatments (e.g., advice of a consultant and/or visual decision aids). Several recent experimental studies confirmed that the research method experiments is a promising and well established method while testing decision making processes in a new product development and/or innovation portfolio management setting (Boulding et al., 1997; Schmidt & Calantone, 2002; Biyalogorsky et al., 2006). Therefore, this dissertation also contributes in the experimental research field. Above all, the analysis of go/stop-decisions has highlighted the interdependencies of the strategic innovation portfolio decisions (Cooper, 1999). Since projects in a portfolio often depend on one another while simultaneously sharing limited resources, this dissertation has analyzed the impact on specific decision making criteria. These criteria may help firms to link their project decision making to the four goals of innovation portfolio management. As a consequence, innovation portfolio management requires input from multiple functions and disciplines, in this dissertation in particular from the experimental research field (Boulding et al., 1997; Schmidt & Calantone, 2002; Biyalogorsky et al., 2006). Future studies should proactively take this characteristic into account.

This dissertation also contributes to the *experimental conjoint analysis*. Conjoint studies are an established method for ranking and analyzing various attributes from the most to the least preferred scenario (e.g., Cattin & Wittink, 1982; Ernst & Schnoor, 2000; Wittink & Cattin, 1953; Gupta, Brockhoff, & Weisenfeld, 1992, Green, Krieger, & Wind, 2001).

Especially, experimental conjoint studies became a promising research field (Shepherd & Zacharakis, 1997; Shepherd & Zacharakis, 1999). I followed the design of this well-known research method to plan my study which I introduced in chapter B and D. Former studies using an experimental conjoint study design contributed in various research fields as venture capital decisions (Patzelt, 2008), entrepreneurs' decisions (Choi & Shepherd, 2004; Monsen, Patzelt, & Saxton, 2009), underperforming alliances (Patzelt & Shepherd, 2008), the development of academic ventures (Patzelt & Shepherd, 2009) or networks and underperforming R&D projects (Patzelt, Lechner, & Klaukien, in press). My experimental conjoint study contributes in this research field and enriches the knowledge of exploiting an innovation project as well as contributes to past empirical work in the go/stop-decision making process (e.g., Cooper et al., 1999; Schmidt & Calantone, 2002).

2.2 Managerial implications

The above studies yield managerial implications for several areas of the innovation portfolio management process. Firstly, it provided decision makers with an improved understanding of the consequences of their own decision making behavior, as these studies analyzed the impact on specific decisions on the innovation portfolio composition. Secondly, these studies suggested additional mechanisms for improving the decision process itself and at the end the overall innovation portfolio. Moreover, the present studies allow developing specific recommendations on how the aims of an optimal innovation portfolio management can be reached by improving the project go/stop-decision process.

In the following, *a checklist for managers* is presented to improve the project go/stop-decision process:

- ✓ Innovation project decisions should not only be based on individual project characteristics; moreover, they should be based on the context of the whole innovation portfolio and the organization's strategic goals.
- ✓ Establish a central and well structured innovation portfolio management team.
- ✓ To improve the overall innovation portfolio do regular review meetings.
- ✓ Extend and objectify decision making criteria.
- ✓ Project kill-decisions should be done systematically and efficient. Establish a tolerant and creative failure culture.
- ✓ Include the idea of portfolio-fit in the decision making process.
- ✓ Use the advice of an external consultant and visual decision aids while pulling the plug.
- ✓ The escalation of commitment trap can be reduced by using more objective decision making criteria.
- ✓ Notify and reduce the sunk cost trap: Stop inefficient innovation projects.
- ✓ For project evaluation the use of tools and the advices of consultants should be balanced along the stage gate process.

The checklist for managers might help decision makers to focus on some key aspects in the decision making process. Especially, the portfolio-fit aspect is a central topic in the context of innovation portfolio management. As discussed before, portfolio-fit decisions can be linked to a firm's innovation activities and the firm's strategy. Moreover, portfolio-fit involves the value maximization and balance within the portfolio including all four goals of innovation portfolio management: 1. financial value of the company's innovation portfolio is

sought to be maximized, 2. firms must find the right balance of their innovation portfolios, 3. portfolio management is designed to focus on core business areas, and 4. organizations set of resources need to fit the number of active innovation projects (Cooper, 1999). To improve the overall innovation portfolio it is therefore necessary to establish an effective decision making culture within the organization which includes the attribute portfolio-fit in the decision making process. These decisions should be integrated in an interdisciplinary decision making team (experienced managers from different divisions within the organization). These managers should do regular and critical review meetings and should evaluate all innovation projects based on strategic, flexible and overall portfolio criteria. Those decision criteria should focus on the four innovation portfolio goals as well as on established decision making criteria (financial aspects of the project, customer and technological aspects).

In the business world, the phenomena escalation of commitment to a losing course of action is an enduring problem of great importance: “good money chasing bad” (Simonson & Staw, 1992). Past research emphasized that managers often fail to invest project resources in other more profitable opportunities. This dissertation underlines, that the advice of an external consultant and visual decision aids potentially aid managers in stay away from over-commitment of resources as these advices help to objectify the decision making criteria. These approaches have the biggest impact before the product is commercialized. Moreover, stop inefficient innovation projects and notify and reduce the sunk cost trap. In the sunk cost trap decision makers justify past decisions, even if the past choices no longer seem valid and old investments are no longer recoverable. Therefore, sunk costs are costs that are irrecoverable. However, it is not just about money, moreover about any type of investment you make (e.g., time, money, effort) is subject to this thinking trap. Therefore, if an innovation project is not fitting the forecast, do a fast and explicit “kill decision”; to terminate an innovation project is not necessarily a failure!

3. Limitation and outlook

3.1. Limitations

I need to underline methodological limitations. Questions about external validity of experiments should be involved, as the decisions are based on a few limited attributes. Decisions in the business world are often more multifaceted and complex. Especially, in the real world, the consequences of specific decision processes are more risky for R&D manager's future career opportunities. In experiments it is difficult to create concerns and pressure being responsible for an expensive project failure for the firm (Schmidt & Calantone, 1998).

Being as realistic as possible in creating the scenarios, I also controlled for extraneous sources of variance. To maximize internal validity, I performed both experiments with R&D managers and not with Bachelor- and/or Master-students, which was challenging given the high time pressure of most R&D managers. In addition, both experimental studies were theoretically justified and tested with R&D managers in Germany and Ph.D. students from the WHU-Otto Beisheim School of Management in Vallendar, Germany. All participants underlined the importance of the research questions and helped to improve the final experimental research designs.

Furthermore, I performed both experimental studies in explicit surroundings using innovation managers in large and medium firms in diverse industries in Germany. I identified those by using the Hoppenstedt database. Future research must analyze, if our findings can be generalized across countries and small- and medium-sized businesses (SMB). Moreover, future studies using a different design (case study, interviews, and/or questionnaire studies) must analyze the robustness of the dissertations findings. They doing so, other statistical techniques should be used which reduce errors and biases gained by HLM and SPSS Statistics.

3.2. Outlook

The two experimental studies give ideas for interesting research avenues. It could be useful to establish a clear definition of the success and failure rates of portfolio-fit and the innovation portfolio management process. As my pre-study interviews have shown, there are many definitions and perspectives about the topic innovation portfolio management in all industries. A standardized approach might help to better connect the research community and managerial practice. Future research is also needed to analyze team dynamics in the decision making process. The interrelated decision making processes within a decision making team is an interesting research topic as it is so far not clear who should finally do the go/stop-decision to reach the best portfolio result.

As most studies deal with single attributes in the decision making process, future research could help to identify more approaches for an optimal and profitable decision processes in the context of innovation portfolio management. Especially, an integration go/stop-experiment is a challenging and promising area for future work. In addition, the discussion indicated that further research is needed to offer a better understanding of the underlying structures and impacts on the decision process.

Furthermore, we should investigate the question why escalation of commitments occurs and what are the best de-escalation strategies. Especially, none of the known approaches fully reduce escalation of commitment tendencies. Therefore, future research is needed to reduce the escalation of commitment trap. Additionally, a longitudinal research (data collection at different points of time) would be a challenging research idea. It would be interesting to analyze and to understand decision making changes within time in an organization. A longitudinal study would also increase validity of my study results. Future research might also try to analyze the decision making processes in other countries, as cultural expects might have an effect on the affection to do go/stop-decisions within the portfolio. Much important research waits to be done

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