MASTER

Evaluation criteria over stages in the new product development process
a qualitative comparative analysis at a high-tech organization

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Evaluation criteria over stages in the new product development process: A qualitative comparative analysis at a high-tech organization

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Abstract

This master thesis investigates which evaluation criteria maximize the likelihood of new product success. It also investigates how strict and objective these criteria must be used over stages in the NPD process. This is done by reviewing relevant NPD literature on evaluation criteria and analyzing thirteen projects within a high-tech organization[1]. Two theoretical frameworks are developed based on gaps in literature. For analyzing these frameworks data was collected and analyzed with the set-theoretic method qualitative comparative analysis.

This study has an explorative nature, i.e. no studies relate evaluation criteria with new product success. In this study combinations of evaluation criteria are found that maximizes the likelihood of new product success. These combinations of evaluation criteria give a clear indication to the high-tech organization to use these criteria. This study contributes to the evaluation criteria that must be used at each phase of the NPD process.

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[1] For confidentiality reasons, the real name of the company is not used in this report. Confidential information can be found in the appendices, which are not publicly available.

Management summary

This report is the result of my master thesis conducted at a high-tech organization. For confidential reasons, the real name of the company is not used in this report. The study focuses on evaluation criteria over stages in the NPD process.

Introduction

The high-tech organization is not sure about their effectiveness and efficiency of their NPD projects and wants to have more insights on these aspects. The general research question will be investigated:

> *"How effective and efficient is the execution of the NPD projects within the high-tech organization?"*

To get more insight into the specific problem of the high-tech organization and to do research on the gaps that are identified during the literature study, several more detailed research questions are formulated. These research questions are based on the cause and effect diagram and the identified gaps. The research questions are the following:

1. *Which evaluation criteria can be used to measure NPD performance overall and per stage in the NPD process?*

2a. *Which evaluation criteria does the high-tech organization currently use at each stage of the NPD process to evaluate the project?*

2b. *What is the level of formality and objectivity of the evaluation criteria used at the stages of the NPD process at the high-tech organization?*

2c. *What is the successfulness of the NPD projects within the high-tech organization compared to objectives and similar projects?*

3. *Which evaluation criteria can best be used to make stage-gate decisions in order to maximize new product success?*

Theoretical background

In order to answer the research questions, first scientific literature is reviewed. This literature review shows that although much literature focuses on the evaluation moments within the stage-gate system and careful evaluation over stages is important, few is known about actual criteria to use and their effect on successful outcomes. Some studies investigate the frequency of evaluation criteria over stages, but literature is rather silence regarding the exact evaluation criteria to use for go/no-go decisions in the stage gate system. Lack of research about evaluation criteria that are most important over stages in the NPD process hampers the development of the knowledge on this topic and asks for further research.

Based on the literature review, three major gaps in current literature are identified: 1) there are only a few studies that focus on new product performance over stages in the NPD project, i.e. only frequency and importance of evaluation criteria over stages are investigated; 2) there is no research about the evaluation criteria which are most important in relation to new products success and 3): there is no integrated research that investigates evaluation criteria per stage and the strict enforcement and objectivity of these criteria.

To address these gaps two frameworks are developed. The first framework addresses the gap regarding the importance of different evaluation dimensions over stages in relation to new product success. In the framework, five evaluation dimensions for measuring NPD performance and the main usage alternatives of these dimensions are shown. Investigation of the use of evaluation criteria in relation to new product success, will demonstrate which combination of evaluation dimensions maximizes the likelihood of establishing new product success.

The second framework addresses the gap regarding strict enforcement and objectivity of different evaluation dimensions over stages in relation to new product success. This framework will focus on the relation between strictly enforced evaluation criteria, objectivity of the criteria and use of specific evaluation dimensions per stage to demonstrate which combinations of strictness and objectivity of a specific dimension maximizes the likelihood of establishing new product success.

Research methodology and empirical research

The study is based on thirteen NPD projects of the high-tech organization. In order to investigate the theoretical frameworks data is collected using a semi-structured interview and two surveys. The semi-structured interview with the project leaders of the NPD projects were held with the aim to recall knowledge and insights of the project and to gain insights of the project for the researcher. The first survey is filled in by the project leader to investigate which evaluation criteria are used over stages. The second survey measures variables that function as input for this study are new product performance, strictly enforced criteria and objective criteria.

This study investigates which combination of conditions maximizes the likelihood of new product success. To achieve this goal the set-theoretic method Qualitative Comparative Analysis (QCA) was used. QCA identifies necessary and sufficient conditions for the outcome new product performance. Each framework will be investigated distinguishing three phases (A, B, C) of the NPD process. Investigation of framework 1 consists of six analyses and framework 2 of twenty-four analyses.

Because of the nature of the data and the limited set of cases, the crisp set analysis is used in this study. In crisp set analysis, the presence of variables is defined using binary values (membership=1/ nonmembership=0). Once measures are collected, the use of crisp set analysis requires original variables that should be calibrated and transformed into crisp sets. The ordinal scaled measures are transformed (or calibrated) into binary values, because QCA uses binary-coded data. To dichotomize conditions according to relevant thresholds, literature is used to derive some general membership rules for the thresholds levels. After calibration of the measures, truth tables are constructed and the solutions are generated by the software-package fsQCA 2.0.

Results

Results of this study are split into descriptive results of use, strictness, objectivity of evaluation criteria, new product success, effectiveness and efficiency of the NPD project and the QCA results.

Based on the survey that was filled in by the project leaders, it is established that all criteria are used in the NPD process by the high-tech organization. Specifically, product criteria are used most at the milestones of the NPD process and financial criteria are used least at the milestones. Strictness of evaluation criteria at the different milestones used by the high-tech organization is not extremely high. All criteria score higher than 0.5, except for financial criteria in the A-phase. All criteria are more strictly enforced if the project proceeds. Product criteria are the most strictly enforced criteria at the milestones and financial criteria are least strictly enforced. All criteria are not strictly enforced in the begin phase of the NPD project by the high-tech organization. Product and market criteria are indicated as most objective criteria at the milestones. In the optimal situation all criteria are fully objective, i.e. evaluation criteria are not open for interpretation of negotiation. However, only half of the financial and market criteria during the milestone of the A-phase are objective.

New product success is split into product performance compared to original objectives (PP) and product performance in general compared to similar projects (PPG). Both performance measures (PPG and PP), have a mean above the middle value (3.5) of the Likert-scale (1-7). On average all projects are quite successful.

Efficiency of all projects is lower than effectiveness. Six projects score lower than 3.5 on efficiency. Project leaders and the innovation manager indicated that the execution of projects was not very efficient. However, they also indicated that effectiveness of the projects is much higher.

The QCA results of framework 1 and 2 are shown below. Only the relevant outcomes of the QCA results for framework 2 are shown.

Dimension	Market	Financial	Product	Process	Intuition
A-phase	Y	N	Y	N	-
B-phase	Y	Y	Y	Y	Y
C-phase	-	N	Y	N	N

Research on framework 1 gives the following results: Use of market and product criteria in the A-phase of the NPD process is necessary to maximize new product success, whereas financial and process criteria must not be used. The QCA analyses for the B-phase shows that all evaluation criteria must be used to maximize new product success. In the C-phase product criteria must be used, and not financial, process and intuition criteria.

Analysis with a specific dimension	Market	Financial	Product	Process	Strict	Objective	Relevant outcome
A-phase (product)			Y		Y	Y	Yes
A-phase (process)				Y	Y		Yes
B-phase (financial		Y			N	N	Yes
B-phase (product)			Y			Y	Yes
B-phase (process)				Y	Y		Yes
C-phase (financial		Y			Y	Y	Yes
C-phase (process)				Y		Y	Yes

Research on framework 2 gives the following results: During the A-phase of the NPD process the product-based dimension must be strictly enforced and objective to maximize new product success. The process-based dimension must be used strict during the A-phase. In the B-phase the financial-based dimension must not used strict and not objective. The product-based dimension must be used objective in the B-phase and the process-based dimension must be used strict in this phase. In the C-phase the financial-based dimension must be used strict and objective. The process-based dimension must be used objective in this phase.

Conclusion, limitations and further research

In this study all research questions are answered. Insights on effectiveness, efficiency and performance of the NPD projects are given to the high-tech organization. The results can instruct managers which evaluation criteria must be used over stages in the NPD process and this study shows how strict and objective evaluation criteria must be used at the different stages of the NPD process. Two theoretical frameworks are developed to identify which evaluation criteria maximize the likelihood of establishing new product success. The findings of this study may be a concrete first step in improving the understanding of evaluation criteria over stages in the NPD process.

For further research, other organizations must be researched to increase the sample size and to generalize the findings of this study. Findings of these comparable initiatives will increase the external validity and allowed the researcher to use fuzzy set QCA instead of crisp set QCA. Also less successful projects and killed projects must be taken into account in further research.

Preface

This master thesis is the final deliverable of my study Innovation Management at Eindhoven University of Technology. The project took place at a high-tech organization in the Netherlands. Performing my graduating project at this organization gave me the opportunity to conduct scientific research in a business environment.

I would like to thank some persons who have supported me during the execution of my graduation project. First, I would like to thank my university supervisor Ed Nijssen for all the time you spent on helping me, but also for your critical view and comments. You gave me trust to fill in this research and motivated me on a constructive way. I would also thank my second supervisor Fred Langerak for your feedback on my reports. Your critically questions together with your advice during our meeting helped me to continue my research successfully.

At the organization I would like to thank Wilma Lukassen and Wim Beeftink for supervision of the project. You provided me a wonderful environment to conduct my study. Our meetings were always interesting and you both helped me finding my way within the organization. I would also like to thank the project leaders of the organization who participate in my research. Without them it was impossible to execute this project.

I would like to thank my parents for giving me the opportunity to complete this study and for supporting me during this project. Also thanks to my friends who supported me during this project. Last, I want to thank my girlfriend Julie, for listening to me and for your support.

Paul van Eersel
Eindhoven, January 2011

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1. Introduction

Organizations develop new products in order to gain profit, market share and satisfy the customers. Therefore, new product development is an essential activity within organizations. NPD could be managed by different formal processes, such as stage gate systems (Cooper, 1990). Gates provide the quality-control mechanism in the process and support go/no-go and prioritization decisions (Cooper, 2001). Important component of the review points are the criteria employed in evaluating new products and making go/no-go and prioritization decisions (Carbonell-Foulquié et al., 2004). These decisions are made based on rational aspects, e.g. product specifications and produt quality, and/or based on irrational aspects, e.g. intuition. Availability of validated evaluation criteria over stages is important in order to make good decisions.

Although much literature focuses on the evaluation moments within the stage-gate system and careful evaluation over stages is important, few is known about actual criteria to use and their effect on successful outcomes. Without relevant evaluation criteria, quality of the critical evaluation of projects remains controversial. Some studies investigate the frequency of evaluation criteria over stages (Hart et al., 2003; Tzokas et al., 2004), but literature is rather silence regarding the exact evaluation criteria to use for go/no-go decisions in the stage gate system. Lack of research about evaluation criteria that are most important over stages in the NPD process hampers the development of the knowledge on this topic and asks for further research.

In this study two frameworks are developed that focus on different evaluation dimensions and its strictness and objectivity in relation to new product success. The first framework focuses on different evaluation dimensions, i.e. product-, financial-, product-, process- and intuition-based dimensions, in relation to new product success. In this study will be investigated which combinations of these dimensions maximize the likelihood of establishing new product success. The second framework focuses on a specific dimension and its strictness and objecivity in relation to new product success. For this framework will be investigated which combinations maximize the likelihood of establishing new product success. The analysis is performed for new product development projects within a high-technological organization.

These combinations are obtained through an analytical technique called qualitative comparative analysis (QCA). QCA is a set-theoretic method that uses Boolean algebra to compare qualitatively attributes in studies of social phenomena (Ragin, 1987, 2000). This technique is chosen, because it focuses on the effects of combinations (sets) of several variables rather than on the average effects of single variables (Fiss, 2007). This is important because typically not just one variable, but a set will ensure success of the NPD project per stage and overall. Research questions will be answered using this technique. Outcomes of the study have implications for NPD literature, use of evaluation criteria at go/no-go decision points and for the business problem of the organization.

The basic purpose of this study is to understand the role of evaluation criteria at different stages of the stage-gate system and its effect on NPD performance. Further to discover the combinations of evaluation dimensions that lead to new product success. Last to advice the high-tech organization how to monitor the NPD process in future.

1.1. Problem definition

This research focuses on the NPD process within a high-tech organization as the general object of analyses. The high-tech organization is not sure about their effectiveness and efficiency of their NPD projects and is therefore interested to get more insights in effective and efficient execution of NPD projects. The general research question will be investigated:

> *"How effective and efficient is the execution of the NPD projects within the high-tech organization?"*

Based on eight preliminary semi-structured interviews with stakeholders, i.e. managers and employees from different departments, it became clear that despite there were no direct problems present in the execution of the NPD projects, the organization is dissatisfied with the current NPD process. The high-tech organization introduces a product development process, which includes reviews at each stage of the stage gate system as given by Cooper (1990). The inefficient NPD process can lead to organizational dissatisfaction. The high-tech organization feels there is an opportunity for improvement from a learning and execution perspective. In this study issues related to the execution problem are investigated primarily.

Currently, the high-tech organization does not have insights in performance of NPD projects over stages and of the new product. The high-tech organization does not have these insights due to the lack of criteria for evaluation of the new product during the development. Not having some evaluation criteria over stages increases the chance making wrong go/no-go decisions. Further, not using evaluation criteria over stages or at the end of the project means that performance is not measured. When performance is not measured, the organization cannot determine how well they are doing (Griffin, 1997). To find out which changes effects new product performance and which improvements really works, new product performance must be measured (Griffin, 1993).

Another cause for missing insights in NPD performance is lack of registration and analyses of the NPD process. Without registration of the execution, the organization cannot monitor and evaluate the execution of the project, what makes getting improvements more difficult. Nevertheless, development costs and lead time of the NPD projects are registered. This registration shows, it is no exception projects cross the budget and time schedule. Insights into crossing budget and time schedule are missing what makes improvements harder.

A cause and effect diagram is developed based on this information. This diagram is presented in Figure 1, which is the basis for the course of the research. To get more insight into the specific problem, several more detailed research questions are defined.

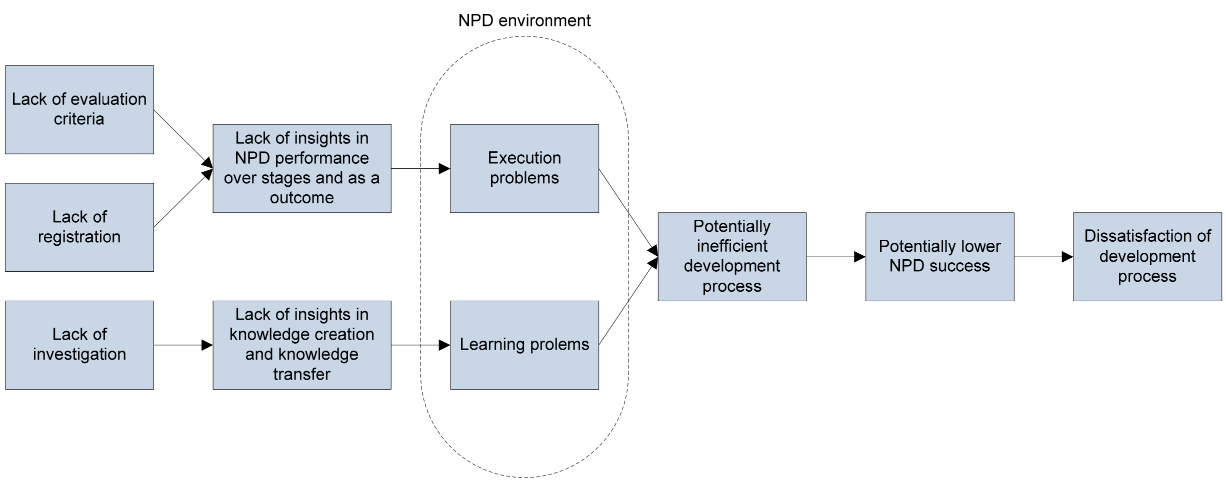

Figure 1 Cause and effect diagram

1.2. Research questions

Issues related to the execution problem stands central in this study. This study focuses on lack of insights in NPD performance per stage and overall. The first research question is answered by a literature study on evaluation criteria per stage and overall. Based on the previous section the following research question is formulated:

1. *Which evaluation criteria can be used to measure NPD performance overall and per stage in the NPD process?*

During this literature study three gaps are identified. The literature study shows that literature on evaluation criteria over stages is rare. In order to get better insight on this topic, case studies of several NPD projects within the high-tech organization are analyzed. Within these cases, evaluation criteria currently used by the high-tech organization at each stage of the NPD process to evaluate the project is investigated. Further, the level of evaluation formality and objectivity will be investigated in order to understand the relation with NPD success. Process management by use of formal processes for product development positively affects NPD success (Cooper & Kleinschmidt, 1995, 2007). Strict enforcement and objectivity of criteria, as discussed by Sethi and Iqbal (2008), will be used. In order to get insight into successfulness of the new product, new product performance must be measured. This will give an understanding of the current state of new product performance. This results in the following questions:

2a. Which evaluation criteria does the high-tech organization currently use at each stage of the NPD process to evaluate the project?

2b. What is the level of formality and objectivity of the evaluation criteria used at the stages of the NPD process at the high-tech organization?

2c. What is the successfulness of the NPD projects within the high-tech organization compared to objectives and similar projects?

The last research question will be answered by comparing and combining the findings from the literature and the empirical study:

3. *Which evaluation criteria can best be used to make stage-gate decisions in order to maximize new product success?*

Answering these research questions will help the high-tech organization solving their problem, lack of evaluation criteria, lack of registration of performance measurement and lack of insights, what results in potentially lower NPD results and dissatisfaction of the development process.

1.3. Company description

This research took place in a high-tech organization, which consists of multiple subsidiaries all over the world. The high-tech organization offers complete systems as well as wide range of equipment for the food industry. The high-tech organization operates in a highly technological and dynamic environment. The research was executed within one of these subsidiaries, which is located in the Netherlands. This subsidiary designs, produces and installs systems for the food industry and offer maintenance for these systems. The high-tech organization is market leader, produces high-quality products and gains profit. To keep their sustainable competitive, the organization constantly works on improving the NPD process to increase NPD performance. To optimize the NPD process, a critically review of the NPD process within the high-tech organization is needed.

The research took place on the basis of NPD projects within this subsidiary. A guiding framework for the NPD process, a stage-gate system, is present in the high-tech organization. This stage-gate system is characterized by multidisciplinairy teams and by clear guidelines for evaluation. The stage-gate system is shown in Figure 2.

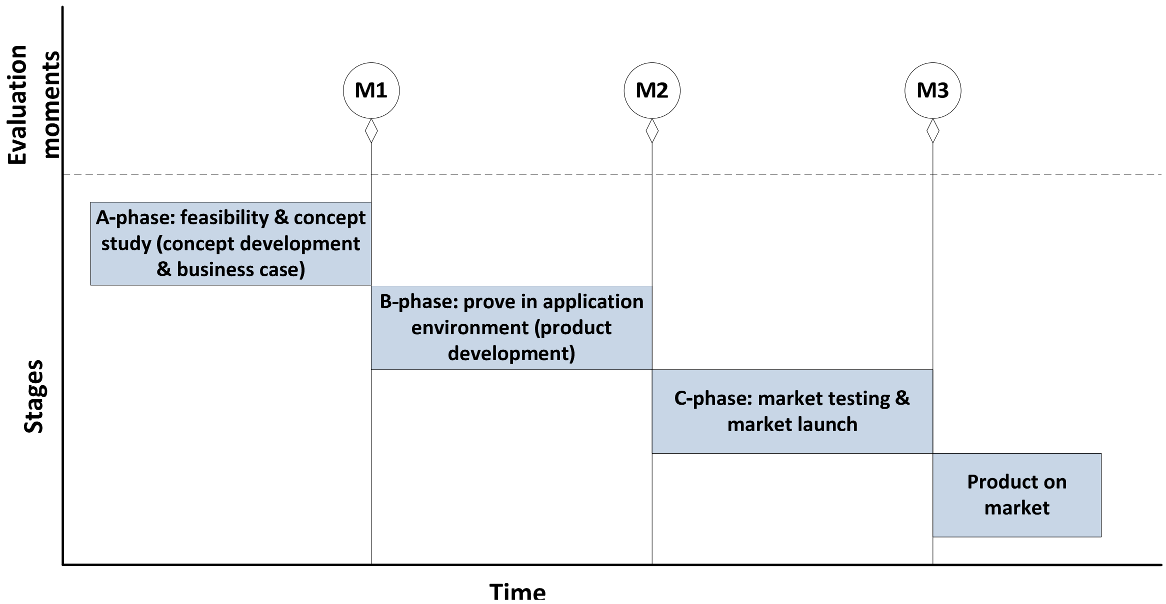

Figure 2 High-tech organizations stage-gate system with its evaluation moments

The high-tech organization uses a stage gate system that distinguishes three phases in its NPD process: the A-phase, B-phase and C-phase. The NPD project is evaluated at the end of each phase, i.e. the evaluation moments M1, M2 and M3. Go/no-go decisions are made based on a presentation, a project report, the product and a discussion with the project leader and the project team about the NPD project. The A-phase contains the feasibility and concept study. Several concepts are developed in this phase and for selecting the concept a more detailed investigation is executed by a business case; the feasibility and concept study. During the B-phase the concept must lead to a product; the development of the product. This development is done in-house, but also in the environment of its application. The C-phase contains a more detailed market test of the product and the market launch.

1.4. Regulative model cycle

During this study the regulative (design) model cycle (van Strien, 1997) is adopted as the primary approach for investigating the research questions, see Figure 3. The regulative model cycle is used to create a design of science, i.e. knowledge will be used as a mean for change. In this cycle the problem solving on a specific case takes place. This holds that the project can be characterized as a design science project. That means NPD performance will be measured and a model will be made which evaluation criteria can be used best to make stage-gate decisions. The main goal of a science-based design is to improve practice.

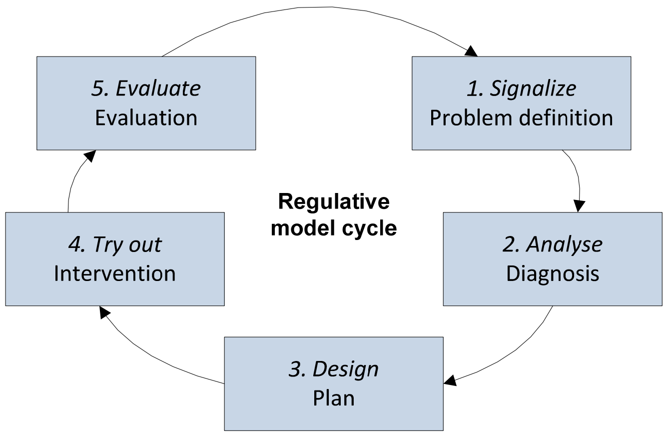

Figure 3 Regulative model cycle (van Strien, 1997)

From a methodological standpoint, the study partly follows the regulative model cycle. This study includes steps related to signalize, analyse and design (1 to 3), but not steps try-out and evaluate (4 and 5) of the regulative cycle.

In the signalize phase, literature about the content of this study is reviewed. Further, preliminary information related to the business problem is collected and the problem definition is defined. The predefined problem is validated to assure that the problem is real and not based on perceptions (Van Aken et al., 2007). The theoretical framework is a product of the literature review. The framework functions as propositions in the analysis. According to Yin (2003), such propositions guide the research and pays attention to something that should be examined within the scope of the study.

In the analysis phase, the NPD process is researched and the current NPD process concerning new product performance will be analyzed with the predefined theoretical framework. In this phase a qualitative and quantitative empirical analysis of the NPD process is made. For this analysis a case study methodology and the set-theoretic method qualitative comparative analysis (QCA) is used.

The resulting diagnosis and structure of the problem leads in the design phase to a plan of action to redesign the process in order to solve the business problem. Due time constraints the redesign is not implemented, so the intervention and implementation of the solution are not part of this study. To the organization, recommendations will be done based on the results. These recommendations are presented as implications for the organization. Therefore this case study only focuses on the first three phases of the regulative cycle: ‘Problem definition’, ‘Analysis and Diagnosis’ and ‘Redesign’.

In the end the study will be evaluated. Results of the study will be discussed, i.e. explanation of the results will be given in the light of existing literature. Further, limitations of the study and possibilities for further research in this research area will be given.

1.5. Report structure

This report comprises four sections that are analogous to the phases conducted during the research and are derived from the regulative model cycle, see Figure 4. The signalize phase of the regulative cycle consists of the introduction, theoretical background and the research methodology. In the analysis phase empirical research is described. The design phase consists of the results, discussion and the conclusion.

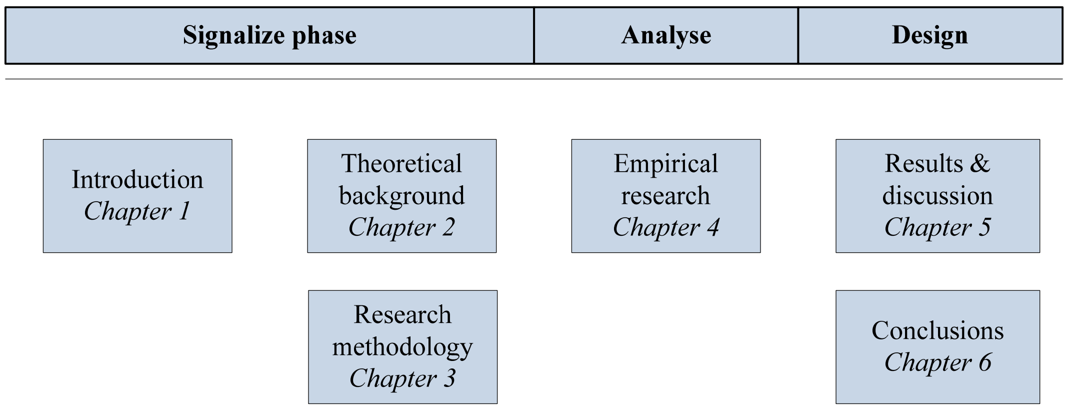

Figure 4 Structure of the report

2. Theoretical background

This chapter will answer the first research question: *Which evaluation criteria can be used to measure NPD performance overall and per stage in the NPD process?* This chapter is structured as follows. First, product development models and the stage-gate system are explained. Second, the measurement of NPD project performance will be discussed, which can be divided into two streams. The first and main stream in the research of performance of NPD projects focuses on the performance of a new product at the end of a project. Will the new product be a success or a failure? The second stream will measure the performance for each stage in the NPD project. Criteria for the evaluation moments over stages will be discussed here. Furthermore the performance model of Blindenbach-Driessen et al. (2010) is discussed. In this literature review, new product performance will be analyzed at the project-level, which is in line with Palmberg (2006), who suggests that firm-level or program-level studies overlook the true diversity of innovation activities within companies. This chapter ends with two theoretical frameworks as a result of the identified gaps.

2.1. NPD performance measurement in the context of the stage-gate system

New product performance is defined as the combination of operational performance and product performance (Blindenbach-Driessen et al., 2010). Operational performance reflects how the NPD project was executed and product performance evaluates the commercial outcome of a NPD project (Blindenbach-Driessen et al., 2010). Both performance measures are used to evaluate the NPD project and its outcome once the product is launched. However, this literature review will mainly focus on the identification of evaluation criteria used throughout the development of the NPD project. Hart et al. (2003) argue that criteria related to new product performance measures, can become the basis for examining the evaluation dimensions of NPD gates. Use of evaluation criteria can be a way of steering the NPD process through the gates.

Much literature focuses on the evaluation moments within the stage-gate system (Cooper, 1990, 2008; Cooper, Edgett & Kleinschmidt, 2002). However, although careful evaluation at each stage-gate is stressed, few is known about actual criteria to use. Nevertheless, it is very important to use validated evaluation criteria over stages in order to make go/no-go decisions. These criteria act as guideposts against which the performance of the NPD project can be evaluated (Saren, 1994).

2.2. Product development models

Nowadays organizations are weighted down by the pressure of higher performance and competition, which is especially true for research and development (R&D) corporate functions and organizations (Zedtwitz, 2002). The NPD process gets a lot of attention, because developing and introducing new products is critical for survival for most companies (Schmidt et al., 2009). In a world of increased competition, managers have the challenge to deal with risks and uncertainties within the NPD process. A product development model can help managers to deal with these uncertainties and risks during the NPD process.

NPD is the process to bring a profitable product from an idea to a commercial sale (Ronkainen, 1985). The standard normative model by Booz et al. (1982) is used to explain NPD. This product development model consists of six principal stages: idea generation, screening, business analysis, product development, testing and commercialization, see Figure 5.

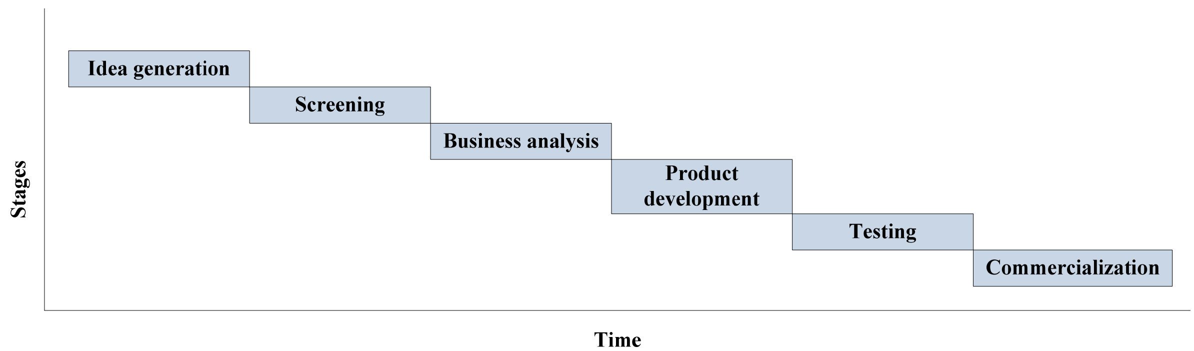

Figure 5 Product development model (Booz, Allen & Hamilton, 1982)

Idea generation is the process for the generation of an unlimited number of new product ideas. Some researchers prefer a stay at home approach to generate ideas, where other researchers prefer that companies have to look in the market for the generation of new ideas (Kortge & Okonkwo, 1989). In the stage s*creening* a preliminary market assessment, a preliminary technical assessment and a global financial assessment is carried out. This stage will eliminate unworthy ideas from ideas that warrant in depth analysis. *Business analysis* of is a more depth analysis of the idea. *Development* consists of selecting from the remaining new product ideas those ideas that warrant further planning and development and have been selected as a project. Specifications are determined and the product will be developed what will result in a prototype. In the stage *testing* the new products will be tested. The activities that are taken in this stage are in-house produce tests, user trials of the product, trial production, market tests and a financial analysis. The *commercialization* stage is the last stage of the NPD process. This stage involves the implementation of the marketing launch plan and the operations plan; here the full-scale production begins.

Despite variation of NPD projects, all of the projects have a level of risk. Cooper (1993) called NPD one of the riskiest, yet most important endeavors of the modern corporation. Jaafari (2001) defined risk as the exposure to loss/gain, or the probability of occurrence of loss/gain multiplied by its respective magnitude. In other words, risk is measured as the probability that an event will occur times the negative impact on performance if the event occurs. The NPD process is characterized by the high rate of new product failure, what results in a high probability of large financial loss. This failure rate is confirmed by Schilling and Hill (1998), who stated that many R&D projects never result in a commercial product. Between 33 percent and 66 percent of all new products that reach the market place fail to generate an economic return (Booz et al., 1982).

The risk level of NPD projects, what could lead to new product failure, can be attributed by uncertainty in NPD. Uncertainty is an information defect, i.e. lack of information (Spender, 1993; Song et al. 2007), which may be defined as the difference between the amount of information required to perform a particular task and the amount of information already possessed (Galbraith, 1973). In a highly dynamic and technological environment, the advent of new architectures and technologies leads to high levels of initial uncertainty about customer preferences and uncertainty about the existing of competitive products, what makes managing the development of a new product a complex managerial task (Bhattacharya et al., 1998; Bacon et al., 1994; Iansiti, 1995).

The breakthrough projects or radical projects, which deal with more process change and more product change, involve high levels of uncertainty (Wheelwright & Clark, 1992). Little information and knowledge about the process and the product is available. NPD projects with a high degree of uncertainty are hard to manage, e.g. decision making in the NPD process is harder due to information and knowledge deficiency. Incremental new products are characterized by less product and process change; the derivative projects.

To increase the chance of new product success, organizations need to understand and manage risks associated with developing new products. One popular way to manage risk is to introduce review points throughout the NPD process (Cooper, 1990). In the next section these review points will be discussed within the stage-gate system.

2.2.1. Stage-gate systems

Use of formal processes for product development will help companies navigating the complex NPD process. 'Process control occurs when managers specify the means used to achieve goals and monitor the activities pursued' (Bajaj et al., 2004, pp. 528). Formal processes for product development, such as the stage-gate system, will increase the probability that a product will be successful in the marketplace (Cooper & Kleinschmidt, 1995). It is the quality and the nature of the process that will drive the performance. Therefore the process must include a sharp, early product definition, before development begins working on the project. It must also include though go/no-go decision points at the end of each stage in the process. The stage-gate system has become a popular system for driving new products to market, and the benefits of using such a robust system have been well documented (Cooper, 1998; Cooper, Edgett & Kleinschmidt, 2004). Regardless the variations of the stage-gate system, such a high quality system has found to yield positive NPD results (Cooper, Edgett & Kleinschmidt, 2002).

Cooper (1990) came up with this stage-gate system as a tool for managing new products. According to Cooper (2008) a stage-gate process is a conceptual and operational map for moving new product projects from idea to launch and beyond; a blueprint for managing the NPD process to improve effectiveness and efficiency. Most best-practice companies have implemented a robust idea-to-launch system (Cooper et al., 2004; Griffin, 1997).

Each stage in the NPD process is designed to gather information and to drive down the unknowns and the uncertainties, what eventually will lead to an effectively managing of the risks (Cooper, 2008). Driving down uncertainties and manage risks will help companies to make a new product with high performance.

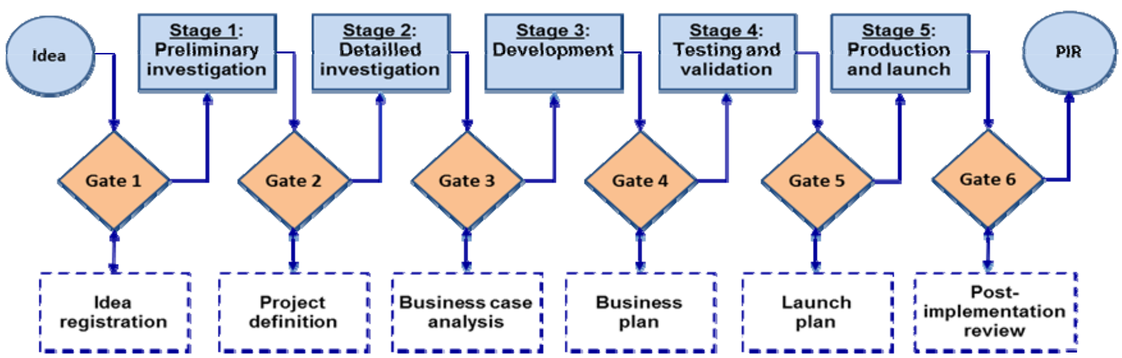

Figure 6 Overview of a 'stage-gate' system (Cooper, 2008)

Figure 6 gives an overview of the stage-gate system (Cooper, 1990). The entrance to each stage is a gate. Gates are normally manned by senior managers who act as gatekeepers. The gate keeping group is multidisciplinary and multifunctional and has the power to approve resources to the project. At each gate of the formal product development process, the gate keeping group evaluates the project against pre-set criteria. The project leader and the team will bring the deliverables to the decision point. According to Cooper (1990), the role of the gate keeping group includes; review the quality of the deliverables, assess the quality of the project from an economic and business perspective, make a go/no-go decision and allocate necessary resources. These gates will help to manage the NPD process. Next section will discuss measurement of NPD performance.

2.3. Measurement of NPD performance

In this section the measurement of NPD performance will be discussed, which can be divided into two streams. First, performance of NPD projects focuses on the performance of a new product at the end of a project and second, the performance for each stage in the NPD project. Criteria for the evaluation moments over stages will be discussed here.

2.3.1. Studies focusing on NPD performance measurement at the end of a project

The main stream in the research of performance of NPD projects focuses on identifying the most suitable performance dimensions to evaluate this performance at the end of a project (Griffin, 1993; Griffin & Page, 1993, 1996). Griffin (1993) and Griffin and Page (1993, 1996) reviewed the most relevant new product performance dimensions at a project-level, however, only after the launch of the product in the marketplace. In their research, a total of seventy-five measures of product development success and failure were generated. Sixteen measures are common across the academic use and firm use. These measures are part of the dimensions customer acceptance, financial performance, product-level and firm-level. These performance dimensions are independent and measure different aspects of success and failure.

The most recent research points out that the three product performance dimensions generally accepted by academics and managers are market-based performance, customer-based performance and financial-based performance (Huang et al., 2004; Lee & O'Connor, 2003). An overview of these three product performance dimensions with their indicators at a project-level can be seen in appendix I. As a basis of this overview, the new product performance dimensions and indicators of Molina-Castillo and Munuera-Alemán (2009), see appendix II, combined with sixteen dimensions of Griffin and Page (1993, 1996) are used. The different new product performance indicators are assigned to the three performance dimensions, by critically reviewing the articles where these performance indicators are discussed.

Market-based performance evaluates the results of a new product, i.e. the level of success of the new product in the market. Several autors, like Cooper and Kleinschmidt (1987), Hultink and Robben (1999) and Lee and O'Connor (2003) have included market-based performance indicators, such as number of units sold, market share and the rate of market penetration. Customer-based performance evaluates the impact of a new product in terms of customer behaviour. Some performance indicators are customer satisfaction, customer acceptance and customer loyalty (Lee & O'Connor, 2003; Langerak et al., 2004). Financial-based performance, the most common used measures, analyze the outcomes of the new product development projects. Some financial indicators are profit, return on investment (ROI) and development cost (Griffin, 1993; Langerak et al., 2004).

Despite the agreement on the fact that use of metrics and measures is important to improved project performance, Cooper et al. (2004) found that still only 30 percent of businesses use such metrics. Companies that do use metrics, generally use about four measures from two different dimensions in determining product development succes (Griffin & Page, 1993). Mostly from the category customer-based performance and financial-based performance. The indicators shown in appendix I are used to evaluate the new product performance at the end of a project. The next subsection discusses evaluation criteria over stages.

2.3.2. Studies addressing NPD performance measurement at each stage in the project

Criteria for evaluation of new product performance at different evaluation gates of the NPD process are few and sketchy at best (Hart et al., 2003), although studies by Hart et al. (2003) and Tzokas et al. (2004) are an exception. More specifically, it has been noticed that 'a major issue that has been overlooked is whether or not the same set of criteria is used at every decision-making point or whether the weights of individual criteria vary from one point to another' (Ronkainen, 1985, pp. 171-172). It is likely to assume that the pool of evaluation criteria that fall into the dimensions from section 2.3.1., could also be used in the gates. Section 2.3.1. gives the best and most complete overview of evaluation criteria available in literature. However, the study of Carbonell-Foulquié et al. (2004) shows that the usage and relative importance of various evaluation critiera are subject to change at different stages of the NPD process. The few articles in which the usage of evaluation criteria at different stages is studied will be reviewed next.

The studies of Hart et al. (2003) and Tzokas et al. (2004) about criteria used to evaluate performance for each gate are quite similar. The study of Hart et al. (2003) investigates the *criteria* that are used most frequently at the NPD evaluation gates and which evaluation *dimensions* are used most frequently at the NPD evaluation gates. The study of Tzokas et al. (2004) investigates which evaluation gates are perceived most important for the eventual success of new products and how firms use different guideposts alongside the various gates of their NPD processes. Both studies investigated which evaluation criteria and dimensions are used most frequently at different stages, based on the same data set. However, Tzokas et al. (2004) also investigates how important they thought each evaluation gate was for the success of their new products. Therefore the latter will be reviewed in more detail.

The study of Tzokas et al. (2004) was focused on the evaluation of performance throughout the NPD process. In their research twenty evaluation criteria were listed; fifthteen criteria conducted from researches from Griffin and Page (1993, 1996) and five other criteria (Hart & Craiq, 1993; Ronkainen, 1985). These criteria were grouped under five dimensions, namely market-, financial-, product-, process-, and intuition-based. Tzokas et al. (2004) investigated the evaluation criteria used by well-experienced NPD managers from the UK and Dutch firms to control performance at different gates of the NPD process.

NPD evaluation gates	Evaluation criteria																			
	Market-based							Financial-based				Product-based				Process-based			Intuition-based	
	Customer acceptance	Customer satisfaction	Sales objectives	Sales growth	Market share	Sales in units	Market potential	Break-Even time	Profit objectives	IRR/ROI	Margin	Product performance	Quality	Product uniqueness	Technical feasibility	Stay within budget	Introduced in time	Time-to-market	Marketing chance	Intuition
Idea screening	49	33	33	27	29	32	59	10	26	9	29	43	29	58	70	12	17	23	32	56
Concept testing	51	38	14	4	6	17	32	7	11	8	13	44	33	26	52	14	16	14	21	23
Business analysis	31	23	54	43	44	64	57	33	55	43	57	25	20	27	29	22	25	31	42	20
Product testing	39	37	12	7	8	19	17	11	13	10	20	67	66	33	63	47	38	31	11	19
Test market	70	64	16	10	13	22	26	11	15	11	20	70	64	27	44	23	33	25	17	16
Post-Launch, short term	60	62	49	41	38	62	34	21	46	22	53	45	42	27	8	12	34	20	22	15
Post-Launch, long term	37	56	44	49	48	55	27	14	47	27	52	36	34	18	4	7	9	4	13	10

Where: ▢ Over 50% of the companies in the sample make use of the criterion at this gate.

Figure 7 List of evaluation criteria at each NPD evaluation stage (Tzokas et al., 2004)

Figure 7 shows the use of evaluation criteria at each NPD evaluation stage. The shadowed boxes indicate cases where a criterion is used by more than 50% of the firms in the sample. In the *idea* *screening*, customer acceptance, market potential, product uniqueness, technical feasibility and intuition are assessed. Gate keeping group wants to make sure that only the ‘right’ ideas are chosen for further exploration. These ideas should have the biggest chance on a commercial success. The gate keeping group also relies on intuition for making a decision, because precise information about market responses and technical requirements is not availabe. In the *concept-testing* gate, results show that gate keeping group evaluates customer acceptance and technical feasibility to decide whether to proceed with the business analysis. In the *business analysis* gate, the decision must be taken whether to start the actual development of the product or not. Herefore criteria are used that reflect financial issues rather than technical issues. The criteria most frequently used are sales objectives, sales in units, market potential, profit objectives and margin. In *product testing* gate, the gate keeping group uses the criteria product performance, quality, technical feasibility and stay within budget most frequently, to test the product has been developed according the specifications set. In *test market* gate, the prototype of the product is evaluated by potential customers. To assess customers’ reaction to the products and its performance the most frequently criteria is the performance and the quality of the product and customer acceptance and satisfaction. In *short-term, postlaunch* gate, the criteria customer acceptance and satisfaction, margin and sales in units are most frequently used. This gate assesses whether the product is performing according to their expectations in the marketplace. In *long-term, postlaunch* the product is well established in the marketplace and its performance is verified. Here the evaluation criteria margin, sales in units and customer satisfaction is used.

Overall, the results suggest that firms use different criteria for evaluation performance at different stages of the NPD process. While criteria such as technical feasibility, intuition market potential are stressed in the early screening gates, a focus on product performance, quality and staying within the budget are considered important after the product has been developed. Customer acceptance, customer satisfaction and unit sales are primary used during and after market launch. Some patterns of usage of evaluation dimensions over the NPD process are as follows, see Figure 8. The market-based dimension is used during the entire NPD process, but are most used the launch of the product. The financial-based dimension is prominent used in the business analyses and after the launch of the product. The product-based dimension is used most frequently at the product and market testing gate.

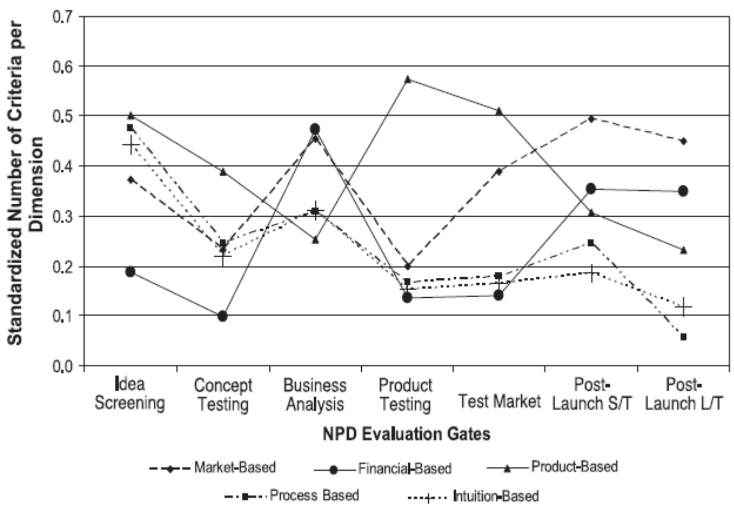

Figure 8 Performance dimensions over NPD gates (Tzokas et al., 2004)

Furthermore the research investigated the importance of evaluation gates for the eventual success of new products. Although all stages are quite important, product testing and market testing gates were perceived most important for eventual success of new products. This result contradicts the study of Weelwright and Clark (1994), who suggest that idea screening and concept testing are the most important stages. This contradiction can be a direct result of the fact that a majority of the products developed by the companies in the sample of the study of Tzokas et al. (2004) are improvements of existing ones.

To a large extent the data set used in the studies Hart et al. (2003) and Tzokas et al. (2004) consists of companies that developed products that are improvements of existing ones. Carbonell-Foulquié et al. (2004) focused in their study on highly innovative products when investigating which evaluation criteria are most frequently used at different gates of the NPD process and the importance of the criteria for each gate in the NPD process. In this study different dimensions were used; strategic fit, technical, customer acceptance, financial and market opportunity dimensions. Some evaluation criteria correspond to the earlier reviewed studies, but others differ. Therefore it is hard to make a comparison between the use and importance of evaluation criteria for incremental and radical products, i.e. a comparison between the outcomes of the study of Carbonell-Foulquié et al. (2004) and Tzokas et al. (2004). The conclusion that the usage and importance of evaluation criteria change over the different stages is in line with the results of Tzokas et al. (2004).

The assumption that evaluation criteria used in the gates should reflect the dimensions, can be partly confirmed. Most evaluation criteria used in the gates can be derived from the market-based performance, customer-based performance and financial-based performance dimensions. However, from the study of Tzokas et al. (2004) can be concluded that different evaluation criteria are used in different stages. Therefore not all dimensions are respresented in all stages or to the same extent.

2.4. The role of strict enforcement, objectivity and frequency of criteria

Where the studies of Hart et al. (2003) and Tzokas et al. (2004) shows the importance of different evaluation criteria at the gates, the study of Sethi and Iqbal (2008) focus on strict enforcement, objectivity and the frequency of criteria.

With regard to the stage-gate system, Sethi and Iqbal (2008) argue that stage-gate controls have the potential to hurt new product performance by restricting learning, see Figure 9. More specific, the authors examine whether the control on a NPD project by strict gate review criteria increases project inflexibility, which in turn leads to increased failure to learn. Learning is critical for effective NPD (Brown & Eisenhardt, 1995; Nonaka & Takeuchi, 1995).

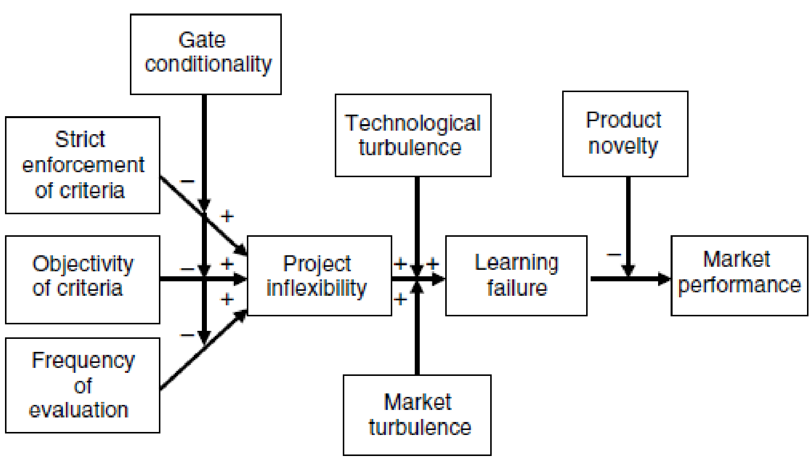

Figure 9 Hypothesized model (Sethi & Iqbal, 2008)

On one hand, managers desire novel products to improve the market success, but on the other hand, managers have a strong faith in the stage-gate system, because it provides them a useful tool for effective control of NPD projects within the organization (Sethi & Iqbal, 2008). Using stage-gate systems with strict evaluation criteria and developing radical new products simultaneously seems problematic according this study. So, managers must consider the context of NPD carefully while applying the stage-gate system.

In this study, the aspects strict enforcement, objectivity and frequency of criteria are part of the hypothesized model, see Figure 9. The studies of Hart et al. (2003) and Tzokas et al. (2004) suggest that firms use different criteria for evaluation performance at different stages of the NPD process. However, these studies do not investigate the strict enforcement, objectivity and frequency of these different evaluation criteria over stages. This study combines these aspects with different evaluation criteria over stages.

2.5. Most recent research: the project performance model

After stage-gate systems were developed for managing NPD and research focus on evaluation criteria to measure performance of new products at the end and during the NPD process, Blindenback-Driessen et al. (2010) developed the performance model. The aim of the study was to develop a performance model to assess the performance of new product innovation projects and to investigate the effects of respondent bias on this model. The model that is developed is shown in Figure 10.

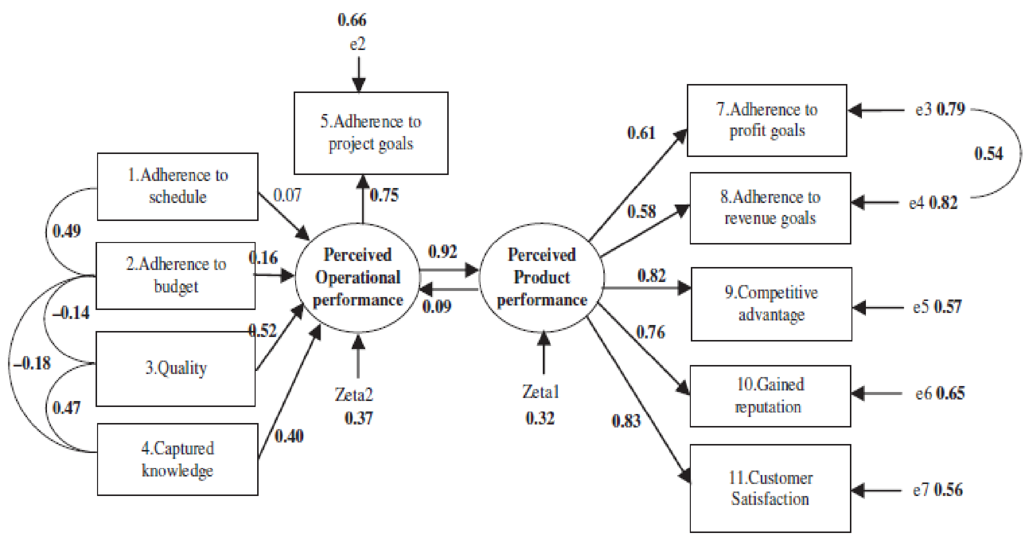

Figure 10 The project performance model (Blindenbach-Driessen et al., 2010)

Performance assessments of NPD projects are typically based on subjective measures (Blindenbach-Driessen et al., 2010). Objectives measures are preferred, but organizations and informants often lack reliable insights into objective financial performance data (Ernst, 2001). Therefore, the product performance dimensions and indicators in the previous sections are often measured following subjective assessments. Subjective data is characterized by respondent bias. The study of Blindenback-Driessen et al. (2010), conclude from their research that project leaders appear to be better informed to assess operational performance, where innovation managers are better in assessing product performance. This will prevent that respondent bias will take place when assessing NPD performance.

The project performance model distinguishes operational performance and product performance. Operational performance relates to meet project goals such as adherence to schedule, budget and quality requirements. Product performance relates to the financial and market performance of the developed product; i.e. the performance of what is developed. Griffin and Page (1996) determined the most important aspects of performance of NPD projects and these will be used for the content of both constructs; i.e. operational performance and product performance. The distinction between only operational and product performance is in line with the models of Hausschildt in Griffin and Page (1993) and Tatikonda and Montoya-Weiss (2001). As shown in Figure 10 operational performance has a significant positive effect on product performance. So, operational and product performance are distinct but clearly related constructs.

The stand-alone models, both the operational performance and the product performance models have a satisfactory fit. The mixed model, where both performance constructs and respondent bias is taken into account, yields realistic estimates, but has a moderate fit. The authors suggest that the mixed model seems the best solution with respect to balancing content and empirical validity.

NPD performance can also be expressed in terms of effectiveness and efficiency. Management of organizations uses pre-specified criteria to assess whether different tasks have been performed efficient and effective. Here, effectiveness reflects a comparison of actual versus intended outcomes, whereas efficiency ratings are based on a comparison of actual versus intended inputs (Hoegl & Gemuenden, 2001). In the case of NPD projects, effective performance entails adherence to predefined qualitative properties of the product, e.g. functionality, reliability, performance, etc. Efficiency is assessed in terms of adherence to schedules and budgets, e.g. staying within the target costs and target date.

2.6. Conclusions for using evaluation criteria

The research question *'Which evaluation criteria can be used to measure NPD performance overall and per stage in the NPD process?'* will be answered next.

Based on literature, (Cooper and Kleinschmidt, 1987; Griffin, 1993; Griffin & Page, 1993, 1996; Huang et al., 2004; Lee & O'Connor, 2003; Hultink & Robben, 1999; Langerak et al., 2004) the following product performance dimensions were identified to measure NPD performance overall: market-based performance, customer-based performance and financial-based performance. Related criteria to these dimensions that can be used to evaluate product performance overall were identified based on the same literature, see appendix I.

Based on literature (Hart et al., 2003; Tzokas et al., 2004), five dimensions were identified to measure NPD performance per stage. These are market-based, financial-based, product-based, process-based and intuition-based dimensions. The studies of Hart et al. (2003) and Tzokas et al. (2004) investigated the evaluation criteria used at different gates of the NPD process, see Figure 7. These studies identify twenty evaluation criteria that are related to these dimensions to measure NPD performance per stage in the NPD process.

2.7. Theoretical frameworks

The theoretical background suggests three major gaps in the current literature: 1) there are only a few studies that focus on new product performance over stages in the NPD project, i.e. only frequency and importance of evaluation criteria over stages are investigated; 2) there is no research about the evaluation criteria which are most important in relation to new products success and 3): there is no integrated research that investigates evaluation criteria per stage and the strict enforcement and objectivity of these criteria. To address these gaps two frameworks are developed.

The first framework addresses the gap regarding the importance of different evaluation dimensions over stages in relation to new product success, see Figure 11. The studies of Tzokas et al. (2004) and Carbonell-Foulquié et al. (2004) lacks investigation of which evaluation criteria are most important over stages in the NPD process. Empirical research on this topic will help organizations to decide which evaluation criteria must be used at different stages in the NPD process.

In the framework, five evaluation dimensions for measuring NPD performance and the main usage alternatives of these dimensions are shown. Investigation of the use of evaluation criteria within different dimensions from Tzokas et al. (2004) in relation to new product success, will demonstrate which combination of evaluation dimensions maximizes the likelihood of establishing new product success. This framework will be tested for each phase of the NPD process as used within the high-tech organization.

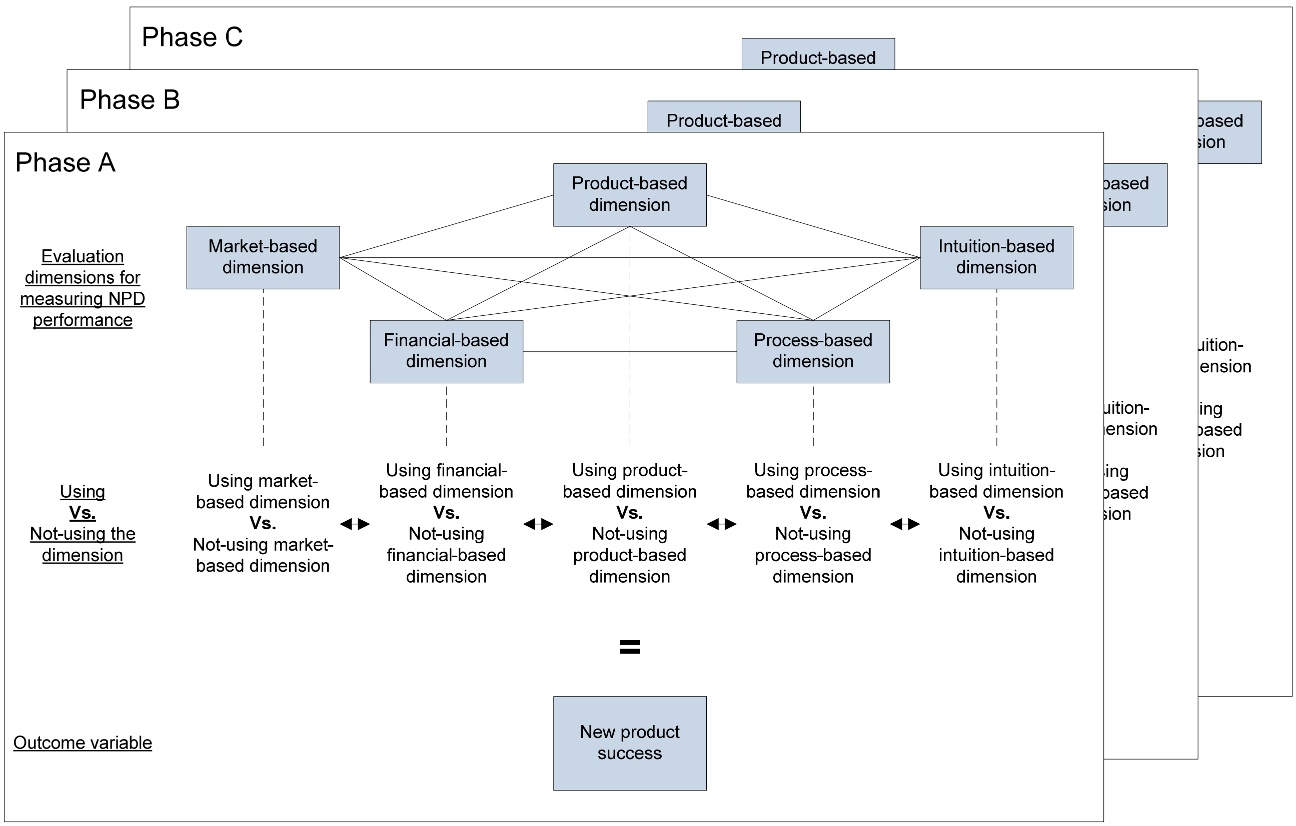

Figure 11 Evaluation dimensions for measuring NPD performance and main usage alternatives: theoretical framework 1

The second framework addresses the gap regarding strict enforcement and objectivity of different evaluation dimensions over stages in relation to new product success, see Figure 12. Where the studies of Tzokas et al. (2004) and Carbonell-Foulquié et al. (2004) lack investigation about most important evaluation criteria over stages in the NPD process, these studies also lack investigation of strict enforcement and objectivity of the evaluation criteria. This framework will focus on the relation between strictly enforced evaluation criteria, objectivity of the criteria and use of specific evaluation dimensions per stage to demonstrate which combinations of strictness and objectivity of a specific dimension maximizes the likelihood of establishing new product success. The intuition-based dimension is not included in this framework, because objectivity of criteria is not applicable for this dimension. Both frameworks are investigated for different stages of the NPD process. A fixed set of evaluation criteria, that proceed from the literature review, will be used.

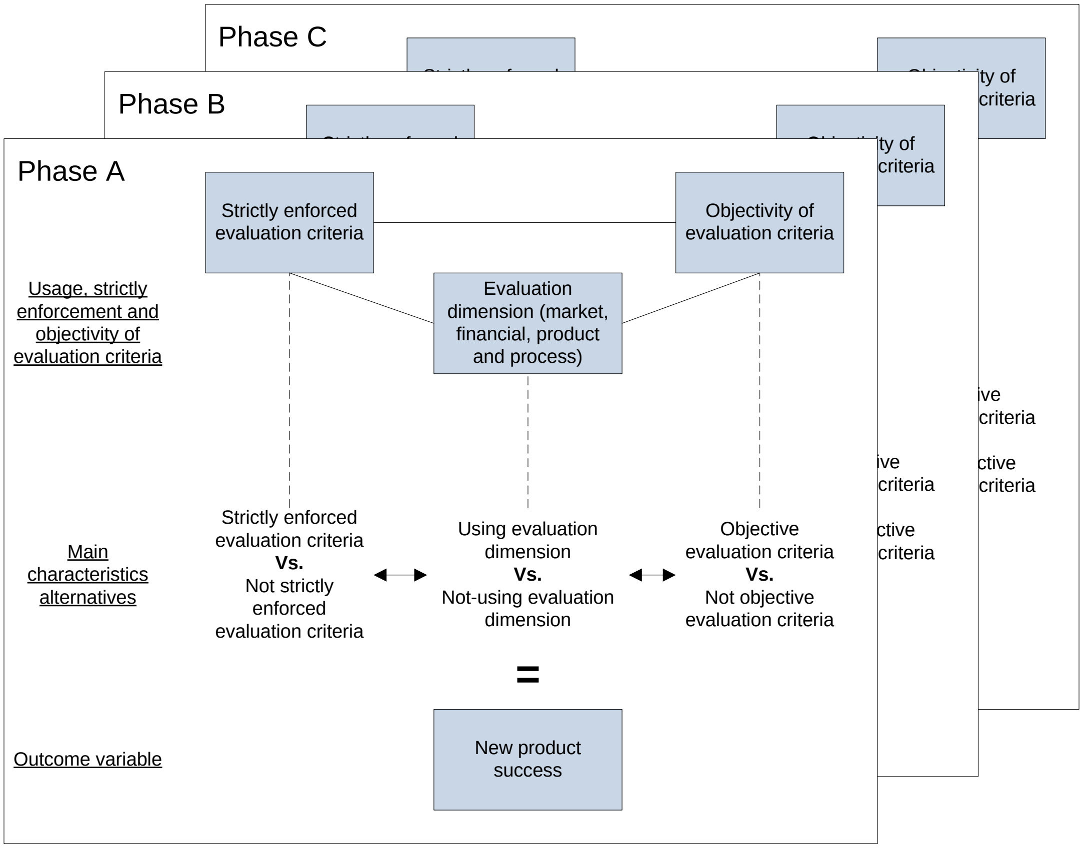

Figure 12 Usage, strictly enforcement and objectivity of evaluation criteria and main characteristics alternatives: theoretical framework 2

While recent research mainly focuses on evaluation of new product performance at the end of a project, this research focuses on evaluation of new product performance over stages. A subdivision of each dimension in relation to new product succes is made instead of an average effect of the dimensions.

The reseacher expects that the market-based dimension is very important in the begin- and end phase of a NPD project. In the begin phase it is more important to focus on market aspects, such as market potential and customer acceptance, than focusing on the product-based dimension. The organization must be sure that the product will meet customers needs and expectations. Intuition, which is based on organizations experiences and thoughts of the market, is also important in the begin phase of a NPD project. In the end phase of a NPD the project market-based dimensions will be important too. Tzokas et al. (2004) shows that companies use market-based dimension in the last phase of the NPD process. The product must fulfill customers needs and be sold to customers. The product-based dimension will be the most important in the middle of the NPD project. In this phase, the product will be developed and must meet all customers needs, i.e. the aspects product performance and the quality of the product. Also all other dimensions will play an important role here.

3. Research methodology

This chapter describes the empirical study undertaken, including analysis and diagnosis. The described research methodology will help to test the theoretical frameworks and to answer the research question 2a, 2b, 2c and 3. First the methodology of data collection and data analysis are discussed. Second the QCA procedure is explained after which measures will be discussed. Finally, methods and instruments used to increase reliability and validity of the study will be discussed.

3.1. Methodology for analysis and diagnosis

Based on the research questions, the case study approach is the most appropriate research method because it focuses on answering 'how and why' questions (Yin, 2009). In this study, thirteen NPD projects of the high-tech organization will be analyzed to get a better understanding of which types of evaluation criteria per NPD stage are associated with more and less favorable NPD outcomes. Also strict enforcement and objectivity of applying these criteria in relation to new product success will be researched. Due to the limited set of cases and exploratory nature of this study it is most closely associated with cross case comparison.

3.2. Method of data collection

Consistent with the mixed method of QCA also a mixed method in this study was used to obtain the data. Interviews were combined with obtaining quantitative scores from the used evaluation criteria. Also internal documents, interviews, meetings and surveys were used for this study. By cross validation the internal reliability and external validity of the data obtained was increased. The data collection took place in several steps. First step was focused on orientation, where later steps involved actual data collection.

In the orientation phase, interviews were held with managers from different departments for a general understanding of the internal organization and the NPD process and to generate the cause and effect diagram, see section 1.1. Also the product development process manual of the high-tech organization and documents of the selected NPD projects, such like progress reports were studied. This provides the researcher insights of the NPD process within the organization and insights of the selected NPD projects.

For selecting NPD projects under investigation, a non-random sampling method was used, which is proposed by Eisenhardt and Graebner (2007) in order to achieve maximum results in theory building research. For this study a recent set of thirteen NPD projects was identified in cooperation with the director of NPD, see appendix III. The sample of this research consists of these project leaders and the director innovation and engineering. Last named only evaluates product performance. The data collection procedure consists of one interview and two surveys.

3.2.1. Interview

Interviews have the strengths that they are insightful, they are targeted at the study topic and they provide perceived causal inferences (Yin, 2003). Interviews have some weaknesses too. This method may be biased by poor constructed questions and response bias. To overcome these biases, questionnaires were predefined; multiple interviewees were consulted and data must was collected using other sources. Internal documents and databases were consulted. Further, meetings were involved about optimization of NPD projects and processes.

Semi-structured interview with the project leaders of the NPD projects were held with the aim to recall knowledge and insights of the project and to gain insights of the project for the researcher. This interview was structured according five categories which have a direct effect on new product success as discussed in the study of Ernst (2002) and Cooper and Kleinschmidt (2007), see appendix IV. Ernst (2002) structured these success factors by using the following five categories: NPD process, organization, culture, role and commitment of senior management, and strategy. The interview questions can be found in appendix V.

3.2.2. Surveys

Two surveys were filled in by the project leaders of the NPD projects. The first survey is filled in by the project leader to investigate which evaluation criteria are used over stages, see appendix VI. Project leaders were asked which evaluation criteria were used in these projects, how strictly adhered these are and the objectivity of these criteria. Also, the importance of different evaluation dimensions to the opinion of the project leaders was indicated. These questions concern the evaluation moments over stages, M1 through M3, see Figure 2. During this session there was a lot of interaction with the researcher.

To identify which evaluation criteria the high-tech organization uses, a specific procedure was used. First a list of fifteen criteria from Griffin (1993, 1996) and five dimensions from Tzokas et al. (2004) was developed. Second, the relevance of these evaluation criteria was established interviewing a project leader and the company supervisor, who are not included in the sample for this study. They were asked which criteria are relevant for the high-tech organization and they were allowed to add criteria also. The results showed that no criteria were added or deleted on this list, see appendix VI. The investigation of strict enforced criteria and objective criteria is based on the study of Sethi and Iqbal (2008). The measures are more elaborated in section 3.5.

The second survey was filled in by the project leader on a project level, see appendix VII. Several variables will be measured via this survey: new product performance (compared to original objectives and compared to similar projects), strictly enforced criteria, objective criteria, knowledge creation, learning of the project, cross functional NPD team and resource support. Constructs and questions are derived from literature, see appendix VIII. Variables that function as input for this study are new product performance, strictly enforced criteria and objective criteria. Other variables are irrelevant for this study. These variables are intended for internal purposes and the results will be summarized in a separate management report.

This survey was also tested by a project leader and the company supervisor who are not included in the sample of the research. Some questions were redefined and some words were changed to create a better fit between the questions and the organizational context; i.e. some 'organization language' was included.

3.3. Method of data analysis

This study investigates which combination of conditions maximizes the likelihood of new product success. To achieve this goal the set-theoretic method Qualitative Comparative Analysis (QCA) is used. This method of analysis is recently introduced to social sciences to narrow the gap between quantitative and qualitative approaches (Ragin, 1987; Fiss, 2007). Set-theoretic approaches are characterized by the idea that relationships between different characteristics are often best understood in terms of set membership. These approaches conceptualize cases as combinations of attributes and emphasize that it is these very combinations that give cases their unique nature (Ragin, 2000). Single cases can belong to a set and can have different degrees of membership in other possible combinations and sets. Sets are thus the single units of analysis in set-theoretic methods (Ordanini & Maglio, 2009).

QCA is a technique that tries to identify multiple paths to an outcome (Ragin, 1987). Also, QCA focuses on the effects of combinations (sets) of several conditions rather than on the average effects of a single condition. This technique can be used for small-to-moderate number of cases in which a specific outcome has occurred, compared with cases where this outcome has not been occurred. QCA is employed in comparative case-oriented research. More precisely, QCA is geared towards multiple-case studies, in a small- or intermediate-N research design (Byrne & Ragin, 2009). Different than traditional statistical analysis, QCA considers configurations of values on the independent variables as cases and does not ask about the independent effect of a variable on the likelihood of an outcome. The main difference between traditional case-oriented methods and QCA is that with QCA the possibility exists to run basic analytic procedures with more than a handful cases (Ragin & Rihoux, 2004).

Through the use of Boolean algebra, where a case is either in or out of a set, set-theoretic methods then identify whether each single attribute can be necessary of sufficient condition for achieving the criterion variable (Ordanini & Maglio, 2009). Therefore, all data is calibrated, into set membership values ranging from 0 to 1.

Because the focus of this research is on combinations of different evaluation dimensions (theoretical framework 1) and an evaluation dimension with their strictness and objectivity (theoretical framework 2) that maximizes the likelihood establishing new product success, the use of a set-theoretic model is relevant and has several advantages. First, as explained above, it may uncover how multiple conditions are connected explicitly to the outcome and distinguish between necessary and sufficient relationships. Hereby, it shows the ability to generalize from a limited set of cases to a larger population. Second, which is already discussed above, set-theoretic methods show how variables combined to create outcomes, where traditional regression models treat variables as competing to explain variation in outcomes (Ordanini & Maglio, 2009). Third, set-theoretic models can address equifinality (Fiss, 2007). This is the existence of different paths leading to the same outcome. Fourth, set-theoretic approaches represent a proper alternative to analyze structural explanations with a small sample size, e.g. $n < 50$, which is often outside the capability of the traditional regression models.

3.4. The QCA procedure

There are three main phases in a QCA procedure: 1) case selection and description, 2) 'the analytic moment' and 3) interpretation (Byrne & Ragin, 2009). Each of these three phases consist of five well-identified practical operations, see Table 1.

Table 1 The QCA procedure

Phase	Practical operations
Case selection and description (chapter 1, 2 and 3)	1. Comparative research design and case selection 2. Gaining case knowledge 3. Defining the outcome of interest 4. Model specifications: selection of conditions 5. Visualizing/synthesizing cases and the models
The analytic moment (chapter 3 and 4)	1. Dichotomization 2. Truth-table exploration and contradiction solving 3. Minimization and logical remainders 4. Solving 'contradictory simplifying assumptions' 5. Minimization, arbitrating between minimal formulae
Interpretation (chapter 5)	1. Factoring out conditions in the minimal formulae 2. Case-by-case interpretation 3. Interpreting cross-case patterns 4. 'Limited historical' generalization 5. Cumulation

During the first main phase, cases are selected and historical information of these cases is collected. Also the theoretical framework is developed (section 2.7), after which the researcher decides how conditions and the outcome variable can be measured best. Data of these measures will be collected as described in section 3.2. This phase is the most time-consuming phase in this study.

The second phase corresponds to the computer-aided part. Data is analyzed with the software package fsQCA 2.0. Original conditions and the outcome variable are calibrated and transformed in crisp or fuzzy sets. Calibration means assessing the measure of a case, not only in relation to the distribution of others' scores on the indicator but also by anchoring that measure to some meaningful points to assess membership (Ordanini & Maglio, 2009). In crisp set analysis, the presence of variables is defined using binary values (membership=1/nonmembership=0). Fuzzy set analysis uses thresholds to further partition membership (Ragin, 2000). In this research crisp-set analysis is used, because of the nature of the data and the limited set of cases (n=13)[2].

Next a truth table will be generated, which lists all possible configurations of characteristics, as well as whether these configurations lead to the outcome in question or not. This table shows different configurations of elements that may cause a certain outcome, where each logical combination has its own row in the resulting truth table. The truth table is also generated by the software package fsQCA 2.0 (Ragin, 2000). Boolean logic is a logical calculus of truth tables and traditionally takes a form of dichotomy (i.e. 0 or 1).

In this phase the so-called contradictory configurations are solved. Contradictory configurations are configurations whose outcome is, in some cases, equal to (1) and in other cases equal to (0), while displaying the same values on the conditions (Byrne & Ragin, 2009). To solve these contradictory configurations several strategies are available (Rihoux & De Meur, 2008). Two key strategies are case-driven: 1) reconsider the dichotomization of conditions and 2) include an extra condition. Contradictions in this study are solved by the first strategy based on case knowledge.

Generated solutions by fsQCA, called complex, intermediate and parsimonious solutions, are formulas which represent combinations of conditions. Often there is more than one minimal formula. The software package cannot arbitrate between some alternative combinations of conditions. In this study, the researcher intervenes and selects the terms that make more sense. This selection is based on case knowledge and expertise.

The last phase deals with the interpretation of the results that stem from the analytic part of QCA. There are three distinct ways to interpret the results of the QCA analysis: case-by-case interpretation, cross-case interpretation and limited historical generalization. Interpretation of the results takes place in chapter 5.

3.5. Measures

The outcome variable is new product success which is split into product performance compared to original objectives and product performance in general compared to similar projects, following the performance assessment of Blindenbach-Driessen et al. (2010). Product performance is measured by six items, where five items are in line with the definition of product performance as formulated by Griffin and Page (1993, 1996). These items are profit goals, revenue goals, market share goals, competitive advantage and customer satisfaction. Based on Blindenbach-Driessen et al. (2010) 'gained reputation', in the market due to the NPD project, was added as a sixth item of

[2] Set-theoretic methods, e.g. QCA, can be used by a small sample size. In csQCA, which only uses dichotomies (0/1), the set of causes is the unit of analysis, so the sample size is always 2^k, where k is the number of causal factors, regardless of the number of observations. With five conditions (causal factors), there are 32 logically possible combinations of conditions. If one dichotomous conditions is replaced by a trichotomous condition, the analysis becomes fsQCA, there are $2^4 * 3^1 = 48$ conditions. With a sample size of 13, too few combinations can be covered, meaning that fsQCA is not applicable.

product performance. Gained reputation is considered as an important performance aspect for all kind of organizations; especially for firms creating complex products (Gann & Salter, 2000; Hoch et al., 2000; Lichtenthaler & Ernst, 2007; Moore, 2005). The items are measured on a seven-point Likert scale.

Blindenbach-Driessen et al. (2010) conclude that project leaders appear to be better informed to assess operational performance, while innovation managers are better in assessing product performance. To increase validity, both project leaders and the manager innovation and engineering assessed product performance in this study. An average of the innovation manager and the project leader is taken for every NPD project.

Table 2 shows the inter correlation between product performance compared to original objectives and product performance in general compared to similar projects. The results shows that there is a significant ($p<0.01$) positive correlation of 0.770. This strengthens the choice to split new product success in these two measures.

Table 2 Inter correlation between product performance compared to original objectives and product performance compared to similar projects

		Product performance compared to original objectives	Product performance in general compared to similar projects
Product performance compared to original objectives	Pearson Correlation	1	,770**
	Sig. (2-tailed)		,002
	N	13	13
Product performance in general compared to similar projects	Pearson Correlation	,770**	1
	Sig. (2-tailed)	,002	
	N	13	13
**. Correlation is significant at the 0.01 level (2-tailed).			

The study of Tzokas et al. (2004) listed twenty evaluation criteria; fifthteen criteria from the study of Griffin and Page (1993, 1996) and five additional criteria (shown in italics) from the studies Hart and Craiq (1993) and Ronkainen (1985). These criteria were grouped under five dimensions, namely market-, financial-, product-, process-, and intuition-based, see table 3. Projectleaders indicate whether or not these evaluation criteria were used at the milestones M1, M2 and M3, using a five-point Likert scale, see appendix VI.

Table 3 Dimensions and evaluation criteria (Tzokas et al., 2004)

Market-based	**Financial-based**	**Product-based**	**Process-based**	**Intuition-based**
Customer acceptance	Break-even time	Product performance	Stay within the budget	*Marketing chance*
Customer satisfaction	Profit objectives	Quality	Introduced in time	*Intuition*
Sales objectives	IRR/ROI	*Product uniqueness*	Time-to-market	
Sales growth	Margin	*Technical feasibility*		
Market share				
Sales in units				
Market potential				

Strictly enforced and objective gate review criteria are measured on a high-level in the survey. The variables were measured through items derived from Sethi and Iqbal (2008), see appendix VII. Because these measures are very general, strictly enforced criteria and objective criteria were measured more specific. For the evaluation criteria used at the milestones, project leaders indicate how strictly enforced and how objective these criteria are. Both measures were measured on a five-point Likert scale, see appendix VI.

3.6. Reliability and validity

Controllability, reliability and validity provide the basis for inter-subjective agreement on research results. Controllability is a prerequisite for the evaluation of validity and reliability. In order to make a research controllable, researchers have to reveal how the research was executed. In this research a high level of controllability is reached by a detailed description of the research and the research methods. The instruments and methods that are used in the research to enhance three types of validity are shown in Table 4. Use of these instruments, procedures and methods will improve the quality of the study.

Table 4 Methods and instruments used to secure the reliability and validity of this study

Method/instruments	Reliability				Validity		
	Bias by researcher	Bias by instruments	Bias by responders	Bias by situational factors	Construct validity	Internal validity	External validity
Multiple case studies			√	√		√	√
Multiple data sources (data triangulation)		√	√	√	√	√	
Semi-structured interviews	√		√			√	
Qualitative Comparative Analysis (QCA)	√					√	
Variables and reliable scales have been used that is based on literature	√	√			√	√	

3.6.1. Reliability

The results of a study are reliable when they are independent of the particular characteristics of that study and can therefore replicated in other studies (Yin, 2003). There are four potential sources of bias that could influence reliability (Van Aken et al., 2007). These are (1) the researcher, (2) the instruments, (3) the respondents and (4) situational factors. The set-theoretic method qualitative comparative analysis (QCA) is used to reduce bias by the researcher. Bias by instruments is reduced using multiple data sources in this study, namely interviews and surveys. Multiple data sources are also used to reduce bias by respondents and by situational factors. Other instruments, procedures and methods that are used to secure reliability of this study are shown in Table 4.

3.6.2. Validity

A research result is valid when it is justified by the way it is generated (Van Aken et al., 2007). The way the research is generated should provide good reasons to believe that the results are true.

Three types of validity are identified by Van Aken et al. (2007): (1) construct validity, (2) internal validity and (3) external validity.

Construct validity is the extent to which a measuring instrument measures what is intended to measure (De Groot, 1969). Construct validity has two sides: the concept should be covered completely and the measurement should have no components that do not fit the meaning of the concept. Variables and reliable scales based on existing literature are used to increase construct validity. Also, multiple data sources are used to enhance construct validity. Internal validity concerns conclusions about the relationship between phenomena, i.e. the results of a study are internally valid when conclusions about relationships are justified and complete (Van Aken et al., 2007). This type of validity is secured by all instrument and methods as shown in Table 4. External validity refers to the generalizability of research results and conclusions to other people, organizations, countries and situations. Use of multiple cases will secure this type of validity.

4. Empirical research

4.1. Analysis of the frameworks

To analyze the empirical data for framework 1, combinations of different evaluation dimensions on new product success, and theoretical framework 2, association of strictness and objectivity with new product success, QCA is applied. QCA identifies necessary and sufficient conditions for the outcome, i.e. new product success will be measured by product performance compared to original objectives (PP) and product performance in general compared to similar projects (PPG).

Each framework will be investigated distinguishing three phases (A, B, C) of the NPD process as explained in section 1.3 Both performance measures will be used for the analysis of these frameworks; i.e. first with the outcome variable PPG and second with the outcome variable PP. This strategy is chosen to increase validity of the results. The positive correlation between the outcome variables PPG and PP will support this strategy, see section 3.5. Investigation of framework 1 consists of six analyses and framework 2 of twenty-four analyses. For framework 2, four dimensions will be tested per phase. As mentioned before, framework 2 will not be tested for the intuition-based dimension, because objectivity of criteria is not applicable for this dimension.

Raw data for framework 1 is shown in appendix IX. More specific, the amount of evaluation criteria used for every dimension, PPG and PP are shown. Two NPD projects had two project leaders. It can be assumed that project leaders in the high-tech organization will have enough knowledge and experiences on an individual level to fill in the surveys. So each project leader can be seen as an independent case, what will increase the sample size.

Raw data for framework 2 is shown in appendix X. For every dimension a table will be shown with the amount of used evaluation criteria within the dimension, the strictness and the objectivity of this dimension. The last two columns show the numbers of PPG and PP. Some projects do not have data for two reasons. First, during the A-phase, two projects did not have an official project leader and one project is not yet finished, meaning that the project is not yet evaluated at the evaluation moment of the C-phase. Second, if the amount of evaluation criteria used is zero, project leaders cannot indicate how strict and objective these criteria were. This influences the amount of cases for the analyses of framework 2, i.e. fewer cases are available for the analysis.

4.2. Crisp sets and calibration

As mentioned before, the software program fsQCA 2.0 is used to investigate the framework (Ragin, 2000). For the analysis a crisp set analysis is used, where fuzzy set analysis is not applicable due the small sample size. Once measures are collected, the use of crisp set analysis requires original variables that should be calibrated and transformed into crisp sets. That means cases are either in (= 1 = membership) or out (= 0 = nonmembership) of a set. All measures are ordinal scales except the measure 'use of evaluation criteria', which is nominal scaled (yes = 1 and no = 0). These ordinal scaled measures must be transformed (or calibrated) into binary values, because QCA uses binary-coded data. To dichotomize conditions according to relevant thresholds, it is best to use empirical (case-based) and theoretical knowledge (Rihoux & de Meur, 2008). Unfortunately, because almost all variables are measured through ordinal scales, theoretical substantial knowledge about the thresholds levels is rare and largely subjective. Therefore literature is used to derive some general membership rules for the thresholds levels.

According to Ordanini and Maglio (2009) previous research showed that great variance in new product success and, because it is reasonable that the success of the new product is often a matter of subjective perceptions, the threshold for the outcome variable will be high. For new product success; product performance compared to original objectives has a threshold of 4.75 and product performance in general compared to similar projects has a threshold of 4.5. Difference between these thresholds can be assigned to the difference in means. The mean of product performance compared to original objectives (5.05) scores higher than the mean of product performance in general compared to similar projects (4.54). Therefore, the threshold of the latter measure will be lower, but much higher than the median of the Likert scale (3.5).

For the market-based, financial-based, product-based, process-based and intuition-based dimensions the threshold is set on the middle of the scale. As shown in Table 3 the dimensions respectively contain seven, four, four, three and two criteria. One exception for this threshold rule is the process-based dimension. From the survey and the interviews with the project leaders becomes clear the middle of the scale for the process-based dimension cannot function as the threshold. Use of one criterion within this dimension does not mean that this dimension is used and has a membership in the set. Furthermore, the criteria 'stay within the budget' and 'introduced in time' are related to each other. Often these criteria are both used or not. Therefore the threshold for this dimension is 2.

Strictly enforced gate review criteria and objective gate review criteria do have thresholds that are similar to the middle score of their standardized numbers (0.5). For every used criterion, project leaders indicate how strict and objective these criteria were used on a five-point Likert scale. Average of these criteria for each dimension is calculated and standardized next. Table 5 summarizes the crisp set conditions for calibrations.

Table 5 The crisp set calibration rules

Variables	Original scaling	Calibration rules	Crisp set values
Product performance compared to original objectives (PP)	Ordinal scale 1-7	If PP ≤ 4.75 If PP > 4.75	0 (fully unsuccessful) 1 (fully successful)
Product performance in general compared to similar projects (PPG)	Ordinal scale 1-7	If PPG ≤ 4.5 If PPG > 4.5	0 (fully unsuccessful) 1 (fully successful)
Market-based dimension (market)	Frequency scale 1-7	If market ≤ 3.5 If market > 3.5	0 (fully unused) 1 (fully used)
Financial-based dimension (financial)	Frequency scale 1-4	If financial ≤ 2 If financial > 2	0 (fully unused) 1 (fully used)
Product-based dimension (product)	Frequency scale 1-4	If product ≤ 2 If product > 2	0 (fully unused) 1 (fully used)
Process-based dimension (process)	Frequency scale 1-3	If process ≤ 2 If process > 2	0 (fully unused) 1 (fully used)
Intuition-based dimension (intuition)	Frequency scale 1-2	If intuition ≤ 1 If intuition > 1	0 (fully unused) 1 (fully used)
Strictly enforced criteria	Standardized scale 0-1	If strict ≤ 0.5 If strict > 0.5	0 (fully not strict) 1 (fully strict)
Objective criteria	Standardized scale 0-1	If objective ≤ 0.5 If objective > 0.5	0 (fully not objective) 1 (fully objective)

4.3. Truth tables

This section explains the use of truth tables and the generation of solutions with the QCA software program. An analysis of framework 2 is used as an example for the explanation.

Data on the crisp sets were analyzed according to recommend truth tables, which are generated by the software package fsQCA 2.0. These crisp set truth tables are generated from the original data and consists $2^5 = 32$ rows for framework 1 and $2^3 = 8$ rows for framework 2. Each row represents a set, where full membership is equal to 1 and nonmembership is equal to 0. Table 6 shows an example of a truth table from the analysis of framework 2, namely the use of financial criteria at the milestone of phase B with the outcome variable PPG. The first row of this table represents the combination use of financial criteria (1) and not using objective (0) and strict criteria (0).

Next, the researcher must develop a rule for classifying some combinations (rows) as relevant and others as irrelevant based on their frequency (Ragin, 2008). Therefore, in all analyses of both frameworks a frequency threshold of 1 is selected. This threshold is chosen, because the total number of cases in all analyses is relatively small (Ragin, 2008). Based on the example six relevant sets are identified. The remaining two sets are deleted, because they had no positive cases in the sample.

Table 6 A truth table form the analysis of framework 2

Set	Financialuse	Financialstrict	Financialobjective	Cases in each set	Degree of consistency
1	1	0	0	3	1.00
2	0	1	1	2	0.50
3	1	0	1	2	0
4	1	1	1	2	1.00
5	0	0	0	1	0
6	0	0	1	1	1.00
7	0	1	0	0	-
8	1	1	0	0	-

The next step is to distinguish configurations that are subsets of the outcome from those that are not. For crisp sets, this determination is made using the measure of set-theoretic consistency as shown in the consistency column. Values below 0.75 indicate substantial inconsistency (Ragin, 2008). Any gaps in the upper range of consistency might be useful for establishing a consistency threshold. Configurations that do meet this threshold are indicated with 1 in the outcome column, see Table 7.

Table 7 The minimized truth table, including set membership in the outcome

Set	Financialuse	Financialstrict	Financialobjective	Cases in each set	Degree of consistency	Membership in the 'Successful Product Performance in General (PPG)'[3]
1	1	0	0	3	1.00	1
4	1	1	1	2	1.00	1
6	0	0	1	1	1.00	1
2	0	1	1	2	0.5	0
5	0	0	0	1	0	0
3	1	0	1	2	0	0

After the truth table is fully constructed, the final outcomes will be provided according to the Quine-McCluskey algorithm. The solution provides a line for each separate path to the outcome, and the output also computes the consistency and coverage measures for each solution term and the solutions as a whole. Consistency measures how often the solution terms and solutions as a whole are subsets of the outcome (Ragin, 2008). These measures also reflect the frequency with

[3] According to a threshold level of consistency set at 1.

which solutions can be considered sufficient conditions for the outcome. Coverage measures how much of the outcome is covered (or explained) by each solution term and the solution as a whole (Ragin, 2008), and they have a similar meaning to that of magnitude effects (R^2) in regression analyses (Ordanini & Maglio, 2009). The solution gives raw coverage and unique coverage. Raw coverage measures the proportion of memberships in the outcome explained by each term of the solution (Ragin, 2008). Unique coverage measures the proportion of memberships in the outcome explained solely by each individual term, excluding memberships that are covered by other solution terms (Ragin, 2008).

In this study the standard analysis is used, because it automatically provides the complex, parsimonious and intermediate solutions. Standard analysis is the recommended procedure, as this is the only way to derive the intermediate solution (Ragin, 2008). Intermediate solutions are usually the most interpretable and best solution (Olsen & Nomura, 2009), but the parsimonious solutions show which conditions are essential to distinguishing between positive and negative cases (Ragin, 2008).

The analysis for the example gives three solutions, which shows the paths leading to new product success, see Table 8. Uppercase conditions must be present (necessary or sufficient) for the outcome variable, where the lowercase conditions must not be present. Consistency values of these solutions are 1. The solution that explains 42.9% of new product success in the sample is the use of financial criteria, non-objective financial criteria and non-strict financial criteria.

Table 8 Intermediate solution with frequency cutoff of 1 and consistency cutoff of 1

	Raw coverage	**Unique coverage**	**Consistency**
financialuse*financialstrict*FINANCIALOBJECTIVE	0.143	0.143	1.00
FINANCIALUSE*financialstrict*financialobjective	0.423	0.423	1.00
FINANCIALUSE*FINANCIALSTRICT* FINANCIALOBJECTIVE	0.286	0.286	1.00
Solution coverage = 0.857			
Solution consistency = 1.00			

5. Results and discussion

In this chapter the results from the surveys and the analyses of the two frameworks with fsQCA 2.0 are discussed. Research questions 2a, 2b, 2c and 3 will be answered in this chapter. First an overview is given on the descriptive statistics and subsequently the frameworks are tested.

Further, the results of this study will be compared with literature findings. This will be done by reflecting on the results of both frameworks with theoretical perspectives that have been discussed in chapter 3. This comparison will point out results that are in line with literature, and thus could be expected. Also, conflicts between the results and literature findings will be discovered.

5.1. Use of evaluation criteria over stages

This section gives an answer to research question 2a: *Which evaluation criteria does the high-tech organization currently use at each stage of the NPD process to evaluate the project?*

Use of market-based, financial-based, product-based, process-based and intuition-based dimensions at the different milestones of the NPD process by the high-tech organization is shown in Figure 13. This figure shows standardized numbers of criteria used per dimension. The standardized number is calculated by the average of all projects. The exact data table is shown in appendix XI. Based on the survey that was filled in by the project leaders, it is established that all criteria are used in the NPD process by the high-tech organization. Specifically, product criteria are used most at the milestones of the NPD process. Standardized number of product criteria at milestone M1, M2 and M3 is respectively 0.96, 0.98 and 0.88. This result differs from the study of Tzokas et al. (2004) where product criteria are used most during the testing phase. Unlike product criteria are used most at all milestones, financial criteria are used least at all milestones M1, M2 and M3 (respectively 0.42, 0.55 and 0.46). The study of Tzokas et al. (2004) results in the same pattern for this criterion. The high-tech organization uses all criteria at the milestone of the B-phase more compared to the A-phase, except for intuition criteria. This criterion is used most at the milestone of the A-phase, what is in line with the study of Tzokas et al., (2004). At the milestone of the C-phase all criteria are used less compared to the milestone of the B-phase. Use of market criteria by the high-tech organization corresponds to the results of the study of Hart et al. (2003).

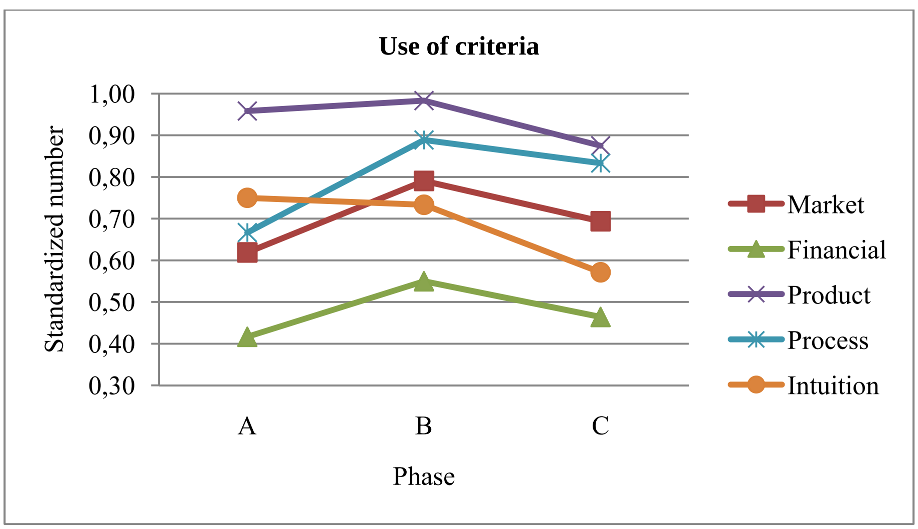

Figure 13 Use of criteria for the dimensions at the milestones of the A-, B- and C-phase

5.2. Level of strictly enforced and objective criteria

This section gives an answer to research question 2b: *What is the level of formality and objectivity of the evaluation criteria used at the stages of the NPD process at the high-tech organization?*

Strict enforcement of evaluation criteria at the different milestones used by the high-tech organization is shown in Figure 14. This figure shows standardized numbers of criteria used per dimension. The exact data table is shown in appendix XI. Overall, strictness of criteria is not extremely high. All criteria score higher than 0.5, except for financial criteria in the A-phase. All criteria are more strictly enforced if the project proceeds. Product criteria are the most strictly enforced criteria at the milestones M1, M2 and M3 (respectively 0.73, 0.78 and 0.83). Financial criteria are least strictly enforced with scores of 0.49, 0.56 and 0.60. All criteria are not strictly enforced in the begin phase of the NPD project by the high-tech organization. Projects are evaluated less strict in the A-phase compared to the C-phase. Less strict evaluation of the project could earlier lead to go-decisions, instead of no-go-decisions when criteria are not reached. A higher level of strict enforcement criteria in the C-phase can be explained by less market- and product uncertainty in this phase. More information is gathered about the market and the product, what makes it easier to use strictly enforced criteria.

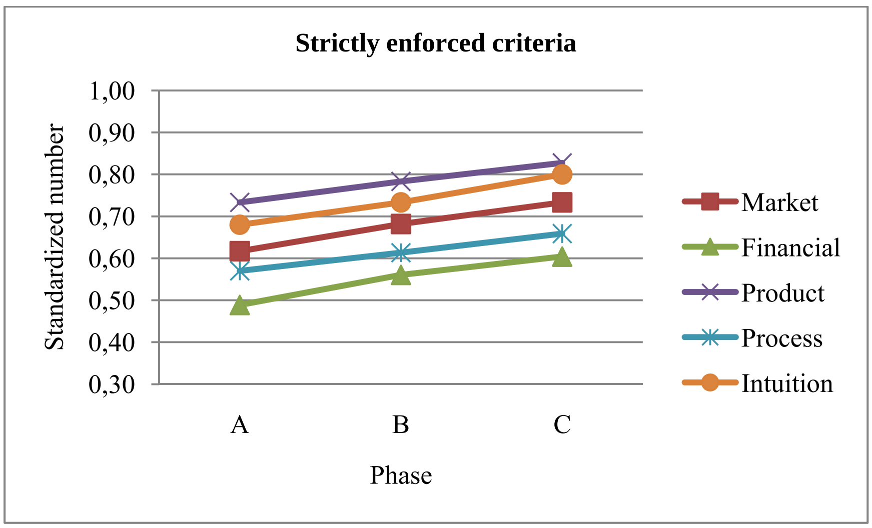

Figure 14 Strictly enforced criteria for the dimensions at the milestones of the A-, B-, C-phase

Figure 15 shows the standardized number of objectivity of the used criteria per dimension. Overall objectivity of criteria scores higher than 0.5. Product and market criteria are indicated as most objective criteria at the milestones. In the optimal situation all criteria are fully objective, i.e. evaluation criteria are not open for interpretation of negotiation. However, only half of the financial and market criteria during the milestone of the A-phase (M1) are objective. The standardized number of these criteria is respectively 0.56 and 0.58. Product and financial criteria become less objective at the milestone of the C-phase, where the other criteria will increase in objectivity. Objectivity of financial criteria will score most badly over all stages.

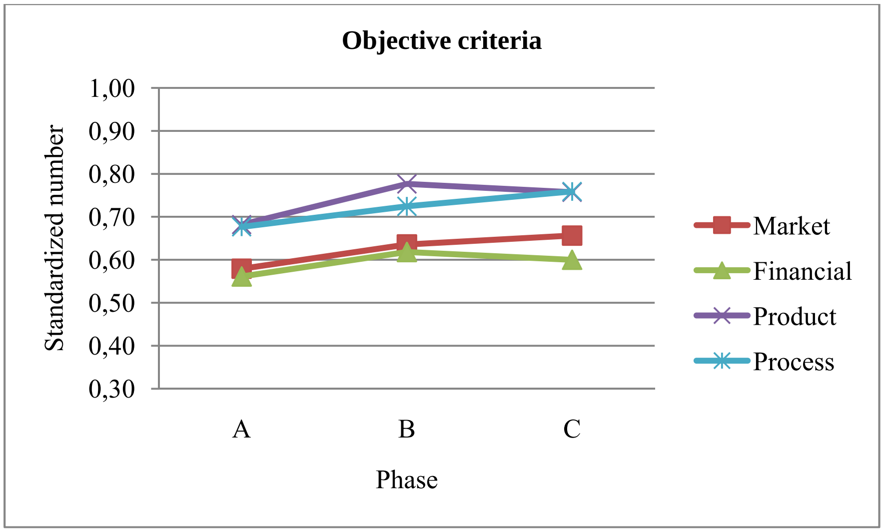

Figure 15 Objective criteria for the dimensions at the milestones of the A-, B- and C-phase

5.3. New product success

This section gives an answer to research question 2c: *What is the successfulness of the NPD projects within the high-tech organization compared to objectives and similar projects?*

New product success is split into product performance compared to original objectives (PP) and product performance in general compared to similar projects (PPG). Table 9 shows the descriptive statistics of product performance. Both performance measures (PPG and PP), have a mean above the middle value (3.5) of the Likert-scale (1-7). On average all projects are quite successful based on these numbers. Some projects will score worse than others, see appendix IX (last two columns). Three projects score below 3.5 based on the outcome variable PPG and no project score below 3.5 based on the outcome variable PP.

Table 9 Descriptive statistics of products performance

	Mean	Std. Deviation	N
Product performance compared to original objectives (PP)	5,0484	,55532	13
Product performance in general compared to similar projects (PPG)	4,5433	,76008	13

5.4. Results of framework 1

With the QCA methodology, combinations of conditions are identified that result in new product success. These conditions are the different evaluation criteria. The findings of the six QCA analyses for framework 1 are shown below. Each analysis is performed for the outcome variable PPG and PP. Results of the analyses with the outcome variable PP are used only, if they differ from the results generated with the outcome variable PPG. As shown before, correlation between PPG and PP is high (r = 0,770). It is expected that results of analyses with these outcome variables will almost be similar.

5.4.1. A-phase

The findings for the QCA analysis for the A-phase (concept development and business case) appear in Table 10 and Table 11. The results for the relationship between evaluation criteria and new product success in the A-phase of the NPD process reveal two combinations of conditions.

The first combination is product- and market-based dimension and not process- and financial-based dimension. The second combination is intuition-, process- and product-based dimension and not financial-based dimension. The whole solution achieves a consistency level of 1.00 and a very good solution coverage (0.75), so these solutions were identified as consistent sufficient conditions. The analysis with outcome variable PP results in exactly the same first combination and another second combination, see Table 11. This solution achieves a consistency level of 1.00 and a good solution coverage (0.63). The similarity of this combination, points out that use of market and product criteria in the A-phase of the NPD process are necessary to maximize new product success, whereas financial and process criteria must not be used.

As expected, in the begin phase of the NPD process, use of market criteria is important. This is in line with the study of Tzokas et al. (2004). The results show that focusing on these criteria will help to achieve new product success. Also product criteria are important in the begin phase of the NPD process. This unexpected result could be explained by the product-driven high-tech organization where this study took place. The high organizational focus on products leads to a high extent of use of product criteria during all phases, see Figure 13.

The intuition-based dimension does not occur in the dominant combination. This is in contrast with the expectation and existing literature (Hart et al., 2003; Tzokas et al., 2004) that suggests that intuition criteria must be used in the begin phase of the NPD process. In this phase, precise information about market responses and technical requirements is missing. It was expected that decision making in the begin phase of the NPD process was based on intuition. Lack of the intuition-based dimension early in the begin phase of the NPD process can be partly explained by the product-driven organization. It seems that product criteria are more relevant than intuition criteria in this phase. Another explanation could be the criterion 'market potential' in the market-based dimension. This criterion is a kind of intuition by the organization.

Table 10 Intermediate solution for the A-phase with outcome variable PPG

New product success (PPG)	Raw coverage	Unique coverage	Consistency
MARKET*financial*PRODUCT*process	**0.375**	**0.375**	**1.00**
financial*PRODUCT*PROCESS*INTUITION	0.375	0.375	1.00
Solution coverage = 0.75			
Solution consistency = 1.00			

Table 11 Intermediate solution for the A-phase with the outcome variable PP

New product success (PP)	Raw coverage	Unique coverage	Consistency
MARKET*financial*PRODUCT*process	**0.375**	**0.375**	**1.00**
MARKET*PRODUCT*PROCESS*INTUITION	0.25	0.25	1.00
Solution coverage = 0.63 Solution consistency = 1.00			

5.4.2. B-phase

The QCA analyses for the B-phase (product development) of the NPD process identified five sufficient sets of conditions in relation to new product success, see Table 12. Results of the QCA analyses for both outcome variables (PPG and PP) are exactly the same. The combination with the highest raw (0.36) and unique (0.36) coverage, includes the market-, product-, financial-, process- and intuition-based dimension. Using all five dimensions in the B-phase maximizes new product success. This (dominant) combination achieves a high consistency of 0.8.

Other combinations differ from the above mentioned combination. However each combination uses product criteria. Product criteria are necessary to maximize new product success. This is consistent with the studies of Hart et al. (2003) and Tzokas et al. (2004). The whole solution achieves a consistency level of 0.90 and a very good solution coverage (0.82). Use of product criteria can be explained by the product-driven organization. The dominant solution shows that product criteria require complements, i.e. all other criteria must be used in the B-phase. This finding is also in line with the expectations.

Table 12 Intermediate solution for the B-phase

New product success (PPG & PP)	**Raw coverage**	**Unique coverage**	**Consistency**
market*financial*PRODUCT*process*intuition	0.182	0.182	1.00
market*financial*PRODUCT*PROCESS*INTUITION	0.091	0.091	1.00
MARKET*financial*PRODUCT*process*INTUITION	0.091	0.091	1.00
MARKET*FINANCIAL*PRODUCT*process*intuition	0.091	0.091	1.00
MARKET*FINANCIAL*PRODUCT*PROCESS* INTUITION	**0.364**	**0.364**	**0.80**
Solution coverage = 0.82 Solution consistency = 0.90			

5.4.3. C-phase

In the QCA analyses for the C-phase (market testing and market launch), four sufficient sets of conditions were found in relation to new product success, see Table 13. The whole solution achieves a consistency level of 1.00 and a very good solution coverage (0.78). All combinations shows different compositions, such that the combination with the highest raw (0.33) and unique (0.33) coverage is the dominant combination. The analysis with outcome variable PP results in exactly the same dominant combination, see appendix XII. This combination uses product criteria, and not financial, process and intuition criteria. This solution achieves a consistency of 1.

In contrast to the expectations, during the C-phase, only the product-based dimension is necessary in relation to new product success, while at the same time intuition-, process- and financial-based dimensions must not be used. Focusing on the product-based dimension seems logic, because the product is tested on the market. As mentioned before, another explanation is the product-driven organization where the study took place. Different than was expected, the market-based dimension does not appear in the dominant combination in order to maximize new product success. However, the market criteria must be used in two other sufficient sets of conditions.

Table 13 Intermediate solution for the C-phase

New product success (PPG)	**Raw coverage**	**Unique coverage**	**Consistency**
financial*PRODUCT*process*intuition	**0.333**	**0.333**	**1.00**
financial*PRODUCT*PROCESS*INTUITION	0.222	0.222	1.00
MARKET*financial*product*PROCESS*intuition	0.111	0.111	1.00
MARKET*FINANCIAL*PRODUCT*PROCESS*intuition	0.111	0.111	1.00
Solution coverage = 0.78 Solution consistency = 1.00			

5.5. Results of framework 2

With the QCA methodology, conditions are identified that result in new product success. In framework 2 the conditions are: a selected dimension (market-based, financial-based, product-based or process-based) and the strictness and objectivity of the selected dimension. Again, analyses with the outcome variable PPG are the basis for the results. Intermediate solutions of the twelve QCA analyses are shown in appendix XII. The results of these QCA analyses are summarized in Table 14. The last column indicates the relevance of the solution. Strictness and objectivity of dimensions are not relevant in two cases: 1) if in the intermediate solution of the QCA analysis with a selected dimension, this dimension do not appear and 2) if the dimension is not necessary according the intermediate solution. In these cases strictness and objectivity of the dimensions does not make sense. A not necessary dimension is indicated with N (no) and non appearance of a dimension in the combination is indicated with -. A necessary condition for new product success is indicated with Y (yes).

Table 14 Results of the QCA analyses for framework 2

Analysis with a specific dimension	Market	Financial	Product	Process	Strict	Objective	Relevant outcome
A-phase (market)	-				Y		No
A-phase (financial		-			Y	Y	No
A-phase (product)			Y		Y	Y	Yes
A-phase (process)				Y	Y		Yes
B-phase (market)	N				Y		No
B-phase (financial		Y			N	N	Yes
B-phase (product)			Y			Y	Yes
B-phase (process)				Y	Y		Yes
C-phase (market)	-				Y	Y	No
C-phase (financial		Y			Y	Y	Yes
C-phase (product)			N		Y	Y	No
C-phase (process)				Y		Y	Yes

5.5.1. A-phase

The intermediate solution for the relationship between the market-based dimension with the strictness and the objectivity of this dimension and new product success in the A-phase of the NPD process reveals one combination of conditions, namely a strict market dimension. However, use of the market-based dimension does not appear in this solution through which this combination does not make sense, see appendix XII. The same counts for the analysis with the financial-based dimension, i.e. use of financial-based dimension does not appear in the solution, see appendix XII.

The intermediate solution with the product-based dimension shows one necessary set of conditions, see Table 15. The QCA analysis with the outcome variable PP results in exactly the same combination. This combination includes use of a strict and objective product-based dimension. The solution achieves a consistency level of 0.78 and a very good solution coverage (0.88).

During the A-phase of the NPD process the product-based dimension must be strictly enforced and objective to maximize new product success. The product-driven character of the organization explains the essential strictness and objectiveness of the product-based dimension. Criteria of the product-based dimension must be used strict at the milestone M1, i.e. not meeting the product requirements completely must have influence on decision-making. Further, use of an objective product-based dimension will help the organization to represent truth and it ensures the management whether the product is developed in line with the customer needs or not.

Table 15 Intermediate solution for the A-phase (product-based dimension)

New product success (PPG & PP)	Raw coverage	Unique coverage	Consistency
PRODUCTUSE*PRODUCTSTRICT*PRODUCTOBJECTIVE	**0.875**	**0.875**	**0.78**
Solution coverage = 0.88 Solution consistency = 0.78			

The results for the relationship between the process-based dimension with the strictness and the objectivity of this dimension and new product success reveals two combinations of conditions, see Table 16. Only the set with strict use of the process-based dimension is relevant. This solution achieves a consistency level of 1 and a good solution coverage (0.375). Use of strict process criteria protects the organization against crossing budget and time schedule.

Table 16 Intermediate solution for the A-phase (process-based dimension)

New product success (PPG)	Raw coverage	Unique coverage	Consistency
PROCESSUSE*PROCESSSTRICT	**0.375**	**0.375**	**1.00**
processstrict*PROCESSOBJECTIVE	0.25	0.25	1.00
Solution coverage = 0.625 Solution consistency = 1.00			

5.5.2. B-phase

The QCA analyses for the B-phase give relevant combinations for the financial-, product-, and process-based dimensions.

In the QCA analyses for the financial-based dimension three sufficient sets of conditions were found in relation to new product success, see Table 17. Two combinations are relevant. The necessary condition is using the financial-based dimension. In one set the financial-based dimension must be used strict and objective and in the other set it must not used strict and not objective. The last mentioned solution has a higher coverage and is therefore dominant. The whole solution achieves a consistency level of 1 and a very good solution coverage (0.857).

Table 17 Intermediate solution for the B-phase (financial-based dimension)

New product success (PPG)	Raw coverage	Unique coverage	Consistency
financialuse*financialstrict*FINANCIALOBJECTIVE	0.143	0.143	1.00
FINANCIALUSE*financialstrict*financialobjective	**0.423**	**0.423**	**1.00**
FINANCIALUSE*FINANCIALSTRICT* FINANCIALOBJECTIVE	0.286	0.286	1.00
Solution coverage = 0.857 Solution consistency = 1.00			

The results for the relationship between the product-based dimension with the strictness and the objectivity of this dimension and new product success reveals one combination of conditions, see Table 18. The product-based dimension must be used objective in the B-phase. This whole solution achieves a consistency level of 0.77 and a very good solution coverage (0.901). Use of objective criteria is also in line with the product-driven character of the high-tech organization.

Table 18 Intermediate solution for the B-phase (product-based dimension)

New product success (PPG)	Raw coverage	Unique coverage	Consistency
PRODUCTUSE*PRODUCTOBJECTIVE	**0.901**	**0.901**	**0.77**
Solution coverage = 0.901 Solution consistency = 0.77			

In the QCA analyses for the process-based dimension three sufficient sets of conditions were found in relation to new product success, see Table 19. Only one combination is relevant. This set includes strict use of the process-based dimension. This solution achieves a consistency level of 1 and a good solution coverage (0.364). Also in this phase, use of strict process criteria protects the organization against crossing budget and schedule time.

Table 19 Intermediate solution for the B-phase (process-based dimension)

New product success (PPG)	Raw coverage	Unique coverage	Consistency
PROCESSSTRICT*processobjective	0.182	0.091	1.00
PROCESSUSE*PROCESSSTRICT	**0.455**	**0.364**	**0.83**
processuse*processstrict*PROCESSOBJECTIVE	0.091	0.091	1.00
Solution coverage: 0.636 Solution consistency: 0.875			

5.5.3. C-phase

The QCA analyses for the C-phase gives relevant combinations for the financial- and process-based dimensions.

The results for the relationship between the financial-based dimension with the strictness and the objectivity of this dimension and new product success reveals two combinations of conditions, see Table 20. Only one set of conditions is relevant. This set includes using strict and objective financial criteria. This solution achieves a consistency level of 1 and a good solution coverage (0.40). Evaluation of the NPD project on financial criteria is important in the C-phase. At the end of this phase the product is launched on the market and financial criteria will play a role. This is in line with Tzokas et al. (2004).

Table 20 Intermediate solution for the C-phase (financial-based dimension)

New product success (PPG)	Raw coverage	Unique coverage	Consistency
Financialuse* FINANCIALSTRICT*financialobjectiv	0.20	0.20	1.00
FINANCIALUSE*FINANCIALSTRICT* FINANCIALOBJECTIVE	**0.40**	**0.40**	**1.00**
Solution coverage: 0.60 Solution consistency: 1.00			

With the QCA analyses for the process-based dimension, two sufficient sets of conditions were found in relation to new product success, see Table 21. Only the set with objective use of process criteria is relevant. This solution achieves a consistency of 1 and a coverage of 0.1. The studies of Hart et al. (2003) and Tzokas et al. (2004) shows the process-based dimension was less used by the organizations in the end of a NPD project. The results show that in the C-phase the process-based dimensions must be used objective. This unexpected result could be explained by the project evaluation. Involved employees can learn from this evaluation based on objective process criteria.

Table 21 Intermediate solution for the C-phase (process-based dimension)

New product success (PPG)	**Raw coverage**	**Unique coverage**	**Consistency**
PROCESSUSE*PROCESSOBJECTIVE	**0.60**	**0.10**	**1.00**
PROCESSSTRICT*PROCESSOBJECTIVE	0.70	0.20	1.00
Solution coverage: 0.80 Solution consistency: 1.00			

6. Conclusion

In this chapter, the main research question will be answered. The similarities and differences between literature and the results of this study led to a number of conclusions. Following on these conclusions, theoretical and managerial implications will be discussed. Next, limitations of this study and suggestions for further research will be given.

6.1. Effectiveness and efficiency of the NPD projects

First an answer is given to the general research question in this study: *"How effective and efficient is the execution of the NPD projects within the high-tech organization?"*.

The project performance model of Blindenbach-Driessen et al. (2010) distinguishes operational performance and product performance. Operational performance is related to meet project goals such as adherence to schedule, budget and quality requirements. Product performance is related to the financial and market performance of the developed product; i.e. the performance of what is developed. More general, operational performance reflects how the NPD project was executed and product performance evaluates the commercial outcome of a NPD project (Blindenbach-Driessen et al., 2010).

NPD performance can also be expressed in terms of effectiveness and efficiency. Management of organizations uses pre-specified criteria to assess whether different tasks have been performed efficient and effective. Here, effectiveness reflects a comparison of actual versus intended outcomes, whereas efficiency ratings are based on a comparison of actual versus intended inputs (Hoegl & Gemuenden, 2001). In the case of NPD projects, effective performance entails adherence to predefined qualitative properties of the product, e.g. functionality, reliability, performance, etc. Efficiency is assessed in terms of adherence to schedules and budgets, e.g. staying within the target costs and target date.

Operational performance and product performance identified by Blindenbach-Driessen et al. (2010) have overlap with effectiveness and efficiency of a project (Hoegl & Gemuenden, 2001). Operational performance is almost identifcal to efficiency, as the same inputs and measures are used, such as budget and schedule. Product performance is almost identical to effectiveness, where both terms focus on the commercial outcome of a NPD project.

Operational performance or efficiency is measured by three items related to project management: adherence to schedule and budget targets and quality (Blindenbach-Driessen et al., 2010). The items are measured on a seven-point Likert scale. Product performance in general compared to similar projects and project performance compared to original objectives are measured as described in section 3.5.

Table 22 shows the effectiveness and efficiency of the NPD projects. Efficiency of all projects is lower than effectiveness. Six projects score lower than 3.5 on efficiency. Project leaders and the innovation manager indicated that the execution of projects was not very efficient. However, they also indicated that effectiveness of the projects is much higher. An explanation for the low efficiency values is crossing of the budget and time schedule. As mentioned before, development costs and lead time of the NPD projects are registered. This registration shows, it is no exception projects cross the budget and time schedule. Product performance in general compared to similar projects (PPG) and product performance compared to original objectives (PP) are already discussed in section 5.3.

Table 22 Effectiveness and efficiency of NPD projects

Case	Operational performance (OP) or efficiency	Product performance in general compared to similar projects (PPG) or effectiveness	Product performance compared to original objectives (PP) or effectiveness
Project 1	3,2	5	5,38
Project 2	3,83	4,5	5
Project 3	3,67	4,88	4,83
Project 4	2,67	3,5	4,75
Project 5	2,83	5	4,92
Project 6	2,58	3,19	4,13
Project 7	3,17	4,75	5,5
Project 8	3,83	4,88	4,58
Project 9	2,67	3,25	4,55
Project 10	4,33	5,38	5,75
Project 11	3,5	5,5	6,17
Project 12	4,17	4,75	5,33
Project 13	4,17	4,5	4,75

6.2. Conclusions

This study proposes a fresh view on evaluation criteria over stages in NPD. Two theoretical frameworks are developed to identify which evaluation criteria maximize the likelihood of establishing new product success. The research questions are answered in this study by research on these frameworks. Answers to the research questions are elaborated throughout this report. In total thirty analyses were performed with the set-theoretic method crisp set QCA to investigate the frameworks. First theoretical implications are discussed after which implications for the high-tech organization are discussed.

6.2.1. Theoretical implications

First, this study offers existing literature more specific insights of evaluation criteria over stages in NPD. As noticed in the literature review, there is no research about the evaluation criteria which are most important in relation to new products success and there is no integrated research that investigates evaluation criteria per stage and the strict enforcement and objectivity of these criteria. There are only two studies of Hart et al. (2003) and Tzokas et al. (2004) that investigates the frequency and importance of evaluation criteria over stages. The findings of this study may be a concrete first step in improving the understanding of evaluation criteria over stages in the NPD process. The analyses for both frameworks shows different combinations for each phase in the NPD process that lead to new product success. Some examples of these specific insights are given next:

For framework 1, in all phases the condition product-based dimension is a necessary, but not sufficient condition. The product criteria are important in all phases to maximize new product success. This study also shows that all evaluation criteria are important and must be used during the product development (B-phase) to evaluate the new product. Next, the findings show that market criteria must be used in the A-phase and B-phase, while financial criteria must not be used in all phases. This suggests that financial criteria are less important than market and product criteria. According to Tzokas et al. (2004) it is during the last fifteen years that the concept of market orientation has gained prominence in the marketing discipline.

Secondly, like the study of Tzokas et al. (2004) and Hart et al. (2003) this study investigates the use of evaluation criteria over stages in the NPD process. In spite of a much smaller sample size, findings can be compared with these studies. The results show that findings are quite similar to the study of Tzokas et al. (2004) and Hart et al. (2003).

Thirdly, another implication is that research on framework 2 offers more insights in the strict enforcement and objectivity of evaluation criteria. Research is done on which combination of an evaluation dimension, its strictness and objectivity lead to new product success. The specific analyses offer an extension in the NPD literature on evaluation criteria over stages in the NPD process.

6.2.2. Implications for the high-tech organization

This study can also offer some implications for the high-tech organization to improve the set of evaluation criteria at the evaluation moments. The results can instruct managers which evaluation criteria must be used over stages in the NPD process. The combinations of evaluation criteria will lead to new product success. The organization can redefine the set of criteria that is used at every evaluation moment (M1, M2 and M3).

Further, this study shows how strict and objective evaluation criteria must be used. Managers can act to these findings at the evaluation moments. For example, process criteria must be used objective at the evaluation moment M3, while at evaluation moments M1 and M2 these criteria must be used strict. All other combinations of framework 1 and 2 are extensively discussed in section 5.4 and 5.5.

The high-tech organization lacks insights in performance of NPD projects over stages and of the new product. This study provides insights on effectiveness, efficiency and its new product success of the NPD projects within the high-tech organization. Further it provides insights in the use of evaluation criteria by the high-tech organization.

In conclusion, this study highlights the combination of evaluation criteria that maximizes the likelihood on new product success. The findings of this study enhance the literature on evaluation criteria over stages in the NPD process and give the organization a suggestion which evaluation criteria must be used over stages.

6.3. Limitations

This study had a number of limitations like any study. Some limitations are related to the explorative nature of this study, some are related to the set-theoretic method QCA. Also other limitations will be discussed. These limitations may also act as stimulus for future research.

6.3.1. Limitations of the explorative nature of the study

The explorative nature of this study limits the existence of theoretical substantial knowledge about the thresholds levels for the conditions and the outcome variable in this study. Some rules for the thresholds levels are not based on theoretical knowledge. For the outcome variable theoretical knowledge is found to determine the threshold level. For the conditions no theoretical knowledge was found. Determination of the thresholds level influences the findings of this study. Lack of theoretical knowledge therefore limits the validation of the chosen thresholds levels.

6.3.2. Limitations of the set-theoretic method QCA

Fuzzy set QCA could not be used in this study because of the small sample size. In crisp set QCA conditions and the outcome variable are calibrated into 0 or 1. Sometimes little change in thresholds changes the crisp set values. In fuzzy set QCA, conditions and the outcome variable can have more fuzzy set values. For example, the outcome variable can have a value of 0,5. Use of crisp set QCA limits the diversity in the calibrated values. Fuzzy set QCA will therefore lead to more accurate findings.

Crisp set QCA gives for some analyses in the theoretical frameworks more combinations in the solution. These multiple combinations do not give the researcher an unequivocal impression about the evaluation criteria to use, which is a limitation of this study. In this study, sometimes five combinations for an analysis are found. In these cases the dominant solution is chosen, i.e. the combination with the highest number of coverage. Also, solutions of the analyses with product performance in general compared to similar projects (PPG) are validated and compared with the solutions of the analyses with product performance compared to original objectives (PP).

6.3.3. Other limitations

A clear limitation of this study for the development of general conclusions is that the research took place in a single organization. For a better understanding it would be useful to also research other organizations. This research was conducted based on the data of only thirteen projects within this organization. Despite this small sample size, the analysis of these projects on evaluation criteria, strictly enforcement and objectivity of these criteria and new product success was extensive. Researching other organizations will also increase the sample size. A larger sample size will increase the generalization of the findings of this study.

Further, this study only took finished NPD projects into account, i.e. the products are launched on the market. To that sense all projects are successful, because the projects pass through all phases and milestones. Product performance of the projects confirms this; it shows that almost all projects score a 4 or higher. So in this study some projects are less successful instead of unsuccessful. This limits the diversity in the outcome variable new product success.

A different moment in time of measuring new product success is a limitation of this study. Some products were just finished, where other products were already finished for several years. The latter products had more time in the market to prove itself, what influences new product success. Future studies must have the same moments in time to measure new product success of the different projects.

The effect of NPD projects on each other was not taken into account in this study. It could be that some projects strengthen other projects in terms of new products success. It is also possible that some products perform badly in the market on itself, but improve other products that are in the same production line. In this study projects are analyzed on a project-level, which is in line with Palmberg (2006).

6.4. Further research

Firstly, other organizations must be researched to increase the sample size and to generalize the findings of this study. Findings of these comparable initiatives will increase the external validity and allowed the researcher to use fuzzy set QCA instead of crisp set QCA.

Secondly, further research must take less successful projects and killed projects into account. Research on evaluation criteria in relation to new product success for less successful projects increases the diversity of the analyses.

Thirdly, in this study was chosen to analyze the projects on a project-level. Further research on the same topic must analyze projects on a program-level. This analysis level will take interaction between different products into account.

Fourthly, in this study no distinction between incremental and radical projects was made. Further research must include both incremental and radical projects in the set of analyzed projects. These findings will give insights of evaluation criteria to use for these different projects.

Finally, in the context of evaluation criteria over stages in NPD, this study is an important first step to identify which evaluation criteria maximizes the likelihood of new product success. Also the use of the set-theoretic method crisp set QCA in this study was new in this context. This study gives a starting point for research on evaluation criteria in relation to new product success.

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