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Management Control in the Front End of Innovation

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ABSTRACT

Should management control the front end of innovation in companies? And if so, how? This thesis examines the use of management control in the front end of innovation, how the different management control mechanisms are associated with front end performance, and how technology and market uncertainty influence this relationship.

The front end of innovation is generally regarded as the most troublesome phase of the innovation process and at the same time as one of the greatest opportunities to improve the overall innovation capability of a company. The front end of innovation has been characterized as a highly uncertain and creative phase, thereby requiring considerable amounts of freedom and independence for those executing front end activities. However, a certain amount of control is necessary to secure the effective use of resources and the achievement of the company's strategic goals. The current findings on management control and its influence on performance in a new product development context in general are conflicting. For example, while many authors argue that behavioral control kills creativity, others emphasize the advantages of improved communication and coordination created by process formalization. Some authors stress the importance of setting specific and challenging strategic goals for development work, yet other articles indicate this inhibits creativity and learning. One challenge in interpreting the conflicting results of existing management control research in a new product development context is the fact that most studies treat the front end of innovation simultaneously with product development projects, thereby averaging the totally different characteristics of these two innovation phases. Studies investigating management control in the front end of innovation are still scarce. This theoretical gap is the focus of this thesis.

This study develops a framework for management control in the front end of innovation and tests hypotheses on the relationship between different management control mechanisms and front end performance. Management control is covered through seven variables: input control, front end process formalization, outcome-based rewarding, strategic vision, informal communication, participative planning, and intrinsic task motivation. Product concept superiority and strategic renewal are used as front end performance indicators, reflecting both the short-term and long-term development needs of the organization. The influence of technology and market uncertainty as potential moderators on the control mechanism–performance relationship is investigated in relation to front end process formalization and outcome-based rewarding. Data from the front end phase of 133 new product development projects from different large and medium-sized Finnish companies have been collected and analyzed. A factor model was used to test the validity of the management control framework and a linear regression analysis used for hypothesis testing.

The results show that management control mechanisms are associated with performance in different manners depending on the performance variable used. Front end process formalization, strategic vision, and intrinsic task motivation were positively associated with product concept superiority. No association was found between input control, outcome-based rewarding, informal communication, participative planning, and product concept superiority. The results show that input

control and intrinsic task motivation were positively associated with strategic renewal in the front end of innovation. No association existed between front end process formalization, outcome-based rewarding, informal communication, participative planning, and strategic renewal. Three significant moderating relationships were found in the study: Market uncertainty positively moderates the positive association between front end process formalization and product concept superiority; Technology uncertainty negatively moderates the relationship between front end process formalization and strategic renewal, i.e. under high technology uncertainty, front end process formalization is negatively related to strategic renewal; Technology uncertainty also negatively moderates the relationship between outcome-based rewarding and strategic renewal, i.e. under high technology uncertainty, outcome-based rewarding is negatively related to strategic renewal.

This study contributes to management control literature by making management control in the front end of innovation the focal point – an area which is still barely touched in management control theory. The findings contribute to the body of knowledge of front end management by showing that management should be actively involved in the front end of innovation and by providing evidence of the importance of this phase on a firm's dynamic capabilities. This thesis contributes to contingency theory also by demonstrating how both market uncertainty and technology uncertainty moderate the association between management control mechanisms and front end performance. The findings have practical implications for management as they show certain mechanisms lead to effective control in the front end of innovation.

Key words: management control, front end, innovation, innovation management, uncertainty, performance

TIIVISTELMÄ

Pitäisikö yritysjohdon ohjata innovaatioprosessin alkupään toimintaa? Jos vastaus on kyllä, niin miten? Tämä väitöskirja tarkastelee johdon ohjausta innovaatioprosessin alkupäässä ja sitä, miten erilaiset ohjausmekanismit vaikuttavat alkupään suorituskykyyn. Lisäksi tutkitaan teknologia- ja markkinaepävarmuuden vaikutusta käytettävien ohjausmekanismien ja suorituskyvyn väliseen yhteyteen.

Innovaatioprosessin alkupäätä pidetään yleisesti kaikkein haastavimpana innovaatioprosessin vaiheena, joka samalla tarjoaa suuria mahdollisuuksia parantaa yritysten innovaatiokyvykkyyttä. Innovaatioprosessin alkupää on epävarma ja luovuutta vaativa vaihe, joka tämän johdosta vaatii huomattavan määrän vapautta ja riippumattomuutta henkilöille, jotka tässä alkupäässä työskentelevät. Toisaalta, tietty määrä ohjausta vaikuttaisi tarpeelliselta, jotta resurssien tehokas käyttö ja yritysten strategisten tavoitteiden saavuttaminen voidaan varmistaa. Nykyinen ymmärrys johdon ohjauksesta ja sen vaikutuksesta suorituskykyyn on tuotekehityskirjallisuudessa ristiriitainen. Jotkut lähteet väittävät, että esimerkiksi toimintatapojen ohjaaminen tappaa luovuuden, samaan aikaan kun toiset lähteet painottavat prosessin määrittämisen positiivisia puolia kuten esimerkiksi parantunutta kommunikointia tai koordinointia. Jotkut lähteet korostavat tarkkojen ja haastavien strategisten tavoitteiden asettamista kehitystyölle, mutta toiset sanovat tämän haittaavan luovuutta ja estävän oppimista. Yksi haaste olemassa olevan tuotekehityskirjallisuuden tulosten tulkitsemisessa on se, että useimmat tutkimukset käsittelevät innovaatioprosessin alkupäätä ja tuotekehitysprojektivaihetta samanaikaisesti, siten keskiarvottaen näiden vaiheiden erilaiset luonteenpiirteet. Innovaatioprosessin alkupäähän kohdistuvia johdon ohjausta käsitteleviä tutkimuksia on harvassa. Tämä liikkeenjohdon teoriassa oleva puute on tämän väitöskirjan kohteena.

Tämä tutkimus muodostaa teoreettisen viitekehyksen johdon ohjauksesta innovaatioprosessin alkupäässä ja testaa hypoteeseja johdon ohjaustapojen vaikutuksesta alkupään suorituskykyyn. Johdon ohjausta tarkastellaan seitsemän ohjaustavan valossa: syötteisiin kohdistuva ohjaus, innovaatioprosessin alkupään määrittely, lopputulokseen perustuva palkitseminen, strateginen visio, epämuodollinen kommunikointi, osallistava suunnittelu, ja sisäinen tehtävämotivaatio. Tuotekonseptin ylivertaisuutta ja strategista uudistumista käytetään innovaatioprosessin alkupään suorituskyvyn mittareina, jotka kuvaavat yrityksen lyhyen ja pitkän tähtäimen tarpeita. Teknologia- ja markkinaepävarmuuden merkitystä ohjaustavan ja suorituskyvyn väliseen yhteyteen tarkastellaan innovaatioprosessin alkupään määrittelyyn ja lopputulokseen perustuvaan palkitsemiseen liittyen. Tutkimuksessa kerättiin ja analysoitiin 133 uuden tuotteen kehitysprojektin aineisto suomalaisista suurista ja keskisuurista yrityksistä. Johdon ohjausmallin soveltuvuus testattiin faktorianalyysillä ja hypoteesit testattiin lineaarisella regressioanalyysillä.

Tulokset osoittavat, että johdon ohjaustapojen yhteys suorituskykyyn riippuu tavasta mitata suorituskykyä. Innovaatioprosessin alkupään määrittely, strateginen visio ja sisäinen tehtävämotivaatio ovat yhteydessä tuotekonseptin ylivertaisuuteen. Tuotekonseptin ylivertaisuudella ei havaittu olevan yhteyttä syötteisiin kohdistuvaan ohjaukseen, lopputulokseen perustuvaan palkitsemiseen, epämuodolliseen kommunikointiin, tai osallistavaan suunnitteluun. Tulokset osoittavat, että syötteisiin

kohdistuva ohjaus ja sisäinen tehtävämotivaatio ovat yhteydessä strategiseen uudistumiseen innovaatioprosessin alkupäässä. Strategisella uudistumisella ei havaittu olevan yhteyttä innovaatioprosessin alkupään määrittelyyn, lopputulokseen perustuvaan palkitsemiseen, strategiseen visioon, epämuodolliseen kommunikointiin tai osallistavaan suunnitteluun. Tutkimuksessa löydettiin kolme tilastollisesti merkittävää moderoivan muuttujan vaikutusta: 1) Markkinaepävarmuus lisää innovaatioprosessin alkupään määrittelyn ja tuotekonseptin ylivertaisuuden välistä positiivista yhteyttä, 2) Teknologiaepävarmuus lisää innovaatioprosessin alkupään määrittelyn ja strategisen uudistumisen välistä negatiivista yhteyttä, ts. innovaatioprosessin alkupään määrittelyllä on negatiivinen yhteys strategiseen uudistumiseen korkean teknologiaepävarmuuden vallitessa, 3) Teknologiaepävarmuus lisää myös lopputulokseen perustuvan palkitsemisen ja strategisen uudistumisen välistä negatiivista yhteyttä, ts. lopputulokseen perustuvalla palkitsemisella on negatiivinen yhteys strategiseen uudistumiseen korkean teknologiaepävarmuuden vallitessa.

Tämä tutkimus lisää teoreettista ymmärrystä johdon ohjauksesta keskittymällä erityisesti innovaatioprosessin alkupäähän, joka on vielä pinnallisesti tutkittu alue liikkeenjohdon teoriassa. Tutkimustulokset antavat lisää ymmärrystä innovaatioprosessin alkupään johtamisesta osoittamalla, että johdon kannattaa aktiivisesti puuttua innovaatioprosessin alkupäähän sekä tuomalla esiin todisteita innovaatioprosessin alkupään tärkeydestä yritysten dynaamisiin kyvykkyyksiin liittyen. Väitöskirja tuo lisäymmärrystä kontingenssiteoriaan havainnollistamalla miten markkina- ja teknologiaepävarmuus vaikuttavat johdon ohjaustapojen ja innovaatioprosessin alkupään suorituskyvyn väliseen yhteyteen. Tutkimustuloksilla on käytännön merkitystä yritysten johdolle sillä ne osoittavat miten tiettyjen ohjaustapojen käyttö lisää innovaatioprosessin alkupään tehokkuutta.

Avainsanat: johdon ohjaus, innovaatioprosessin alkupää, innovaatio, innovaatio-johtaminen, epävarmuus, suorituskyky

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Espoo, November 2009

Jarno Poskela

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1 INTRODUCTION

***"Since the purpose of a business is to find and keep a customer, then the only two things that matter are marketing and innovation, everything else is a cost."* – Peter F. Drucker**

1.1 Background

The foundation for successful new product innovations is created in the front end of innovation. The term *front end of innovation* refers here to the first phase of the innovation process, i.e. the phase before the formal development project is launched, and it consists of a set of organizational activities aimed at developing new product concepts[1]. The overall structure and the main characteristics of the future product are all decided in the front end of innovation, which then strongly affects subsequent new product development (NPD) activities. For example, it is estimated that typically 75 – 90% of the final production costs of a product are defined when the concept has been formulated[2]. Prior studies indicate that these early front end activities represent the most troublesome phase of the innovation process, and at the same time one of the greatest opportunities to improve the overall innovation capability of a company[3]. The front end of innovation nourishes the NPD pipeline by producing new product ideas and results in a well-defined product concept, clear development requirements, and a business plan aligned with the corporate strategy[4]. In addition, the front end should produce a decision on how the product concept will be developed further. However, despite the recognized importance and great development potential of the front end of innovation, e.g. compared to the product development project phase, there has still been relatively little research on the best practices related to this[5].

The front end of innovation has a very strategic nature and needs more attention from management. Important strategic selections embodied in a product concept and related to, for example, target markets, customer needs, value propositions, the expected product price, the main product functionalities, and the predominately used

[1] Adopted from Koen et al. 2001
[2] Shields and Young 1991
[3] Reid and de Brentani 2004, Herstatt et al. 2004, Nobelius and Trygg 2002, Kim and Wilemon 2002, Cagan and Vogel 2002, Zhang and Doll 2001, Koen et al. 2001
[4] Kim and Wilemon 2002
[5] Nobelius and Trygg 2002, Kim and Wilemon 2002, Koen et al. 2001

technologies are typically all made at this stage[6]. A critical activity in the front end is to ensure that decisions and choices serve the best interests of the company and fulfill its long-term strategic objectives. However, strategic guidelines might be missing, misleading, or too general to ensure an efficient link between strategies and operative-level activities, thus making decisions uncertain and unsystematic. Product concepts can be endlessly moving targets when there is no comprehensive strategy adopted to direct the innovation processes[7]. Other familiar symptoms reflecting possible front end failure are new product initiatives that are cancelled halfway through because they do not match the company's strategy and delayed top-priority new product ideas that suffer from a lack of prioritization of assignments[8]. These problems emerge when senior management do not communicate their strategic-level expectations, such as the product's core benefits, choice of market segments and pricing of products, to the development team[9]. Strategic statements can also be too abstract and give no direction to front end activities[10].

Lack of management involvement is caused by insufficient models and knowledge on how to control the front end. An opportunity to influence strategic choices in NPD is naturally greatest at the beginning of the innovation process, when new products are conceptualized. However, the typical real involvement pattern shows that management gets heavily involved in the initiative after the design phase has already been completed, just when large financial commitment is actually needed or when problems become visible[11]. Unfortunately, the ability to influence the outcome then without considerable and costly redesign effort is low. Management should invest their time proactively to confirm that critical choices made in the front end phase are strategically feasible from the company's point of view[12]. The knowing what to do, when to do it and how to do it makes the difference between the successful and unsuccessful involvement of management in the product innovation context[13].

[6] Bonner et al. 2002, Smith and Reinertsen 1998, Wheelwright and Clark 1992
[7] Wheelwright and Clark 1992
[8] Englund and Graham 1999, Khurana and Rosenthal 1997
[9] Khurana and Rosenthal 1997
[10] Smith and Reinertsen 1998, Reinertsen 1994
[11] Smith and Reinertsen 1998, McGrath 1996, Wheelwright and Clark 1992
[12] Smith and Reinertsen 1998, McGrath 1996, Wheelwright and Clark 1992, Wheelwright and Clark 1992b
[13] McGrath 1996

The term *management* refers here to individuals such as research and development (R&D) directors, technology directors, or idea portfolio owners, who are responsible (based on their organizational position) for ensuring that front end activities fulfill strategic objectives and serve the development needs of the organization. The effective control of an organization's strategic intent requires both the creative freedom to innovate and deliberate interventions to ensure that individuals are working efficiently toward predefined goals. An appropriate balance between freedom and constraints, empowerment and accountability, top-down direction and bottom-up creativity, intended and emergent strategy, and experimentation and efficiency is the key in management control in organizations that need room for innovations and flexibility[14]. *Management control* in this thesis is defined as a management activity that is used to maintain or alter patterns in front end activities to achieve successful results[15]. Thus the term control here does not simply mean a traditional type of control, i.e. assurance of the execution of existing strategic plans, but it also covers the bottom-up experimentation that aims at strategic renewal. Management control is executed through the use of *management control mechanisms*, which refer to the procedures and tools, such as resource allocation, process formalization, or rewarding, that management uses to maintain or alter patterns in the front end.

Management control in the front end is extremely challenging compared to other phases of the innovation process. The creative nature of the front end makes it difficult to use a command type of control, but still certain controllability is needed to secure the effective use of resources and the achievement of the company's long-term objectives. Several studies have shown that the nature of separate innovation process phases are totally different in terms of task characteristics and people involved, and have concluded that they should be managed accordingly[16]. Research on the management control of information system development projects indicates that types of management control and control mechanisms change when the initiative proceeds from the idea stage toward commercialization[17]. Simple output-based controls are preferred over behavior control at the beginning of projects[18]. Another study revealed

[14] Simons 1995
[15] Adapted from Simons 1995
[16] Kirsch 2004, Koen et al 2001, Nixon 1998, Zien and Buckler 1997, Rockness and Shields 1984
[17] Kirsch 2004, Choudhury and Sabherwal 2003
[18] Choudhury and Sabherwal 2003

that informal control modes dominated over formal methods in the requirements definition phase, whereas formal methods were taken into use in the implementation phase[19]. One challenge in interpreting the sometimes conflicting results of existing management control research in the NPD context is due to the fact that these studies have investigated NPD projects as a whole without considering the separate phases of projects, e.g. differences between the front end phase and the development project phase. The importance of studying the different phases of the innovation process separately has been widely acknowledged[20].

Prevailing understanding is that there are contextual limits in terms of uncertainty for different control mechanisms. One may justifiably wonder whether any type of control is appropriate, i.e. has a positive effect on performance in the highly uncertain and even chaotic front end phase. By building on the premises of contingency theory[21] and discussions of task uncertainty, this thesis tests the moderating role of market and technology uncertainty on the relationship between the use of control mechanisms and front end performance. Front end performance is measured here in terms of product concept superiority[22] and strategic renewal[23], reflecting both the short-term and long-term needs of the front end of innovation.

One of the starting points for this survey research was my own notion in my qualitative studies that industrial companies are currently intensively developing systematic approaches for managing and controlling the front end phase[24]. A qualitative interview study indicated that many of those development interventions focused on creating a modified stage-gate model for the front end phase. The current theoretical understanding is in line with the stated concerns of practitioners, who are afraid of the possible influence that a strict stage-gate process may have on innovativeness in the front end of innovation.

[19] Kirsch 2004
[20] Kirsch 2004, Davila 2000, Olson et al. 1995, Rockness and Shields 1984
[21] See e.g. Burns and Stalker 1966, Galbraith 1973, Donaldson 2001
[22] Cooper 1994, Shenhar et al. 2001, Kleinschmidt et al. 2005, Herstatt et al. 2004, Griffin and Page 1996
[23] Kleinschmidt et al. 2005, Herstatt et al. 2004 , Cooper and Kleinschmidt 1987
[24] Poskela 2006

The role and value of NPD activities has increased both in private and public organizations as well as in the Finnish economy overall. Public discussion emphasizes the importance of innovations as economic growth while industrial production facilities are steadily being transferred to countries with lower labor costs. NPD and the development of other kinds of innovations are seen as sources of economic prosperity in a new competitive era. New knowledge related to the management of innovations and NPD therefore has value for both industrial companies and Finnish society in general.

The rationale and necessity for this doctoral thesis arises from the above reasoning. Existing theoretical literature on front end management and management control is not complete, providing room for new empirical findings and theoretical insights[25]. The literature review indicates that there is a need for scientific empirical studies that focus on studying the use of different management control mechanisms especially in the front end of innovation. Practical relevance arises from various industrial needs to continuously advance the innovation capability of companies and improve innovation processes. Empirically-tested management models and instructions are of importance for decision makers in industrial companies.

1.2 Research questions and research objectives

This research aims to offer a new theoretical and empirical insight into the effectiveness of management control mechanisms in the front end of innovation. The research problem of the thesis can be stated as follows: **How can the use of different management control mechanisms explain front end performance?** This can be elaborated further to include the following research questions:

1. How are different types of management control mechanisms related to front end performance?
2. How do market uncertainty and technology uncertainty influence the relationship between management control mechanisms and front end performance?

[25] See e.g. discussion by Kirsch 2004

To answer these questions, the following research objectives were set:

1. To review and analyze the literature on management control and innovation management, especially in the front end of innovation.
2. To conceptualize the key characteristics related to management control, the front end of innovation and front end performance.
3. To develop a set of empirically testable hypotheses related to the association between management control mechanisms and front end performance.
4. To empirically test the hypotheses including designing the measurement instrument, operationalizing measurement constructs, defining the appropriate sample, collecting the data, analyzing the data with appropriate methods, and evaluating the validity and reliability of the study.
5. To discuss empirical and theoretical implications of the findings as well as to give suggestions for future research.

1.3 Scope and delimitations

The following delimitations were set for this research to guarantee a manageable scope and accuracy of the study. This thesis focuses only on the first part of the innovation process, i.e. the front end of innovation. It investigates the development of tangible product innovations only, and other innovation types, such as service, production process, organizational or marketing innovation, are not covered. This is due to the expected differences in these innovation types in terms of their management and execution process. Minor product modifications are also excluded in this study because the front end of innovation is normally ignored in this kind of development. The thesis covers a full range of incremental and radical product innovations where the conceptualization of the product is carried out thoroughly.

Management control is approached from the management's perspective. In other words, the collected empirical data is based on the responses of management-level persons on how the front end of innovation is controlled. The unit of analysis is a completed front end project and especially the association between the management control mechanisms used and front end performance. The front end project level (a single project level) approach allows the actual control practices that are usually

hidden behind formal and defined company policies, a common problem in organizational research[26], to be revealed. Responses are neither just 'average' answers to the use of certain control mechanisms, thus resulting in more truthful findings. The empirical investigations cover both medium-sized and large companies operating in different industrial fields. The empirical data is limited to Finnish and foreign-owned companies conducting NPD activities in Finland.

Theoretically, this thesis is based on front end, innovation, and NPD management literature in terms of the context in which management control is applied. Management control literature forms another key theoretical foundation for the study.

1.4 Research approach and methods

The scientific paradigm of this study rests on the positivistic approach. The scientific paradigm can be defined as *"the basic belief system or worldview that guides the investigator, not only in choices of method but in ontologically and epistemologically fundamental ways"*[27]. The positivistic paradigm has influenced the choices related to the research strategy and research design, as well as the ontological and epistemological considerations and methodological choices made in this study.

Under the positivistic paradigm, the focus is on the relationship between the object of study and the theoretical framework, which is constructed in order to explain the phenomenon[28]. The science is considered as value-free in this study and I have worked as an objective analyst of a concrete social reality. I have distanced myself from the investigated phenomenon and collected the empirical data afterwards through a mail survey. From the epistemological point of view, I am an objectivist. I have focused on facts and fundamental laws, and have tried to find causalities in the investigated phenomenon. In other words, I have represented realist ontology and have aimed to test and verify priori-created theory-based hypotheses through measuring empirical reality in an objective manner.[29]

[26] March and Sutton 1997
[27] Guba and Lincoln 1994 p. 105
[28] Remenyi et al. 1988
[29] Easterby-Smith et al. 1991, Remenyi et al. 1988, Guba and Lincoln 1994, Burrel and Morgan 1979

According to Remenyi et al.[30] *"…the best business research should lead to the development of guidelines by which individuals in positions of responsibility can manage their business responsibilities more efficiently and effectively"*. The research work of this thesis is based on empirical investigations carried out in Finnish industrial organizations. Moreover, this thesis concerns applied empirical research, which is deeply rooted in theory with the purpose of providing new theoretical and empirical insights for organizations, allowing them to improve the efficiency and effectiveness of the front end of innovation.

This study relies on a quantitative, hypothetic-deductive research approach according to the positivistic tradition. The main research method is a quantitative survey which was constructed based on the extensive review of the theoretical literature and existing research. Based on the analysis, 22 hypotheses were created. Hypotheses were tested with a data set collected from the Finnish industry. The data set includes in total 133 usable answers. Exploratory factor analysis and multiple linear regression analysis are the main data analysis methods used in this study. The appropriateness of research design and the measurement instrument are discussed in terms of their reliability and validity. Finally, the results and their generalizability are presented and discussed in terms of supporting and conflicting findings compared to existing theory.

1.5 Structure of dissertation

This report consists of seven sections. Chapter 1 introduces the background and rationale of investigating management control in the front end context. In addition, the research questions, research objectives, the research scope and delimitations, the research approach and research methods are illustrated in this chapter.

Chapter 2 reviews the existing literature that is relevant to this study. First, management control and management control mechanisms are examined in general and more specifically in the NPD context. Second, the front end of innovation is explained in terms of the typical ways of organizing the front end and the activities conducted in the front end. Third, front end performance and the performance variables used are explained. Fourth, the role of market uncertainty and technology uncertainty as important moderators is discussed.

[30] Remenyi et al. 1988 p. 27

Chapter 3 focuses on hypotheses development based on existing theory and empirical studies. Seven management control mechanisms and their association with front end performance are reviewed. Chapter 4 introduces the research methods of the study and describes the empirical sample, survey design, statistical methods, construct operationalizations, and validity and reliability considerations used. The chapter explains the logical steps in this study from the methodological point of view.

Chapter 5 presents the results of the study. The descriptive statistics and the results of the correlation analysis and regression analysis are examined. Chapter 6 focuses on discussing the results and linking the findings to the current body of knowledge. The implications of using management control mechanisms in terms of their influence on front end performance are reviewed.

Finally, Chapter 7 draws conclusions on this research. Its contribution to the current body of knowledge, the managerial implications, the limitations of this study, and the directions for future research are all discussed in this section.

2 LITERATURE REVIEW

***"There is no doubt that creativity is the most important human resource of all. Without creativity, there would be no progress, and we would be forever repeating the same patterns."* – Edward de Bono**

The literature review starts with a thorough analysis of the different forms of management control, including a short review of the development of management control theory, the identification of different types of management control, a review of existing research on management control in general and also in the NPD context, and in particular an illustration of the control mechanisms used by the management. This is followed by a review of front end management literature. This section illustrates the work activities that are typically executed in the front end of innovation; those activities in which management tries to exert its influence by implementing control through different control mechanisms. In addition, some general models that are typically used to organize the front end are introduced. The following section discusses the complex issue of front end performance in depth. This gives a theoretical base for operationalizing measurement constructs for front end performance. The next chapter examines market uncertainty and technology uncertainty as potential contingency factors in NPD studies.

2.1 Management control and control mechanisms

Management control is one of the key organizational activities that helps organizations to work effectively. Management control has been stated to be an important aspect of organizational design[31], fundamental management activity[32], critical activity for organizational success[33], and also a central feature of all human organizations[34]. Merchant states that management control should especially be targeted in the strategically important areas of organizations, such as NPD[35]. The traditional 1970's and 1980's view of control emphasized managerial actions as confirming that activities conform to existing strategic plans. The present

[31] Eisenhardt 1985
[32] Jaworski 1988
[33] Merchant 1982
[34] Otley and Berry 1980
[35] Merchant 1982

understanding of management control is as a function of divergent requirements between creativity and innovativeness, and intended goal achievement[36].

The literature offers a variety of different definitions of management control. Modernist organization theory, which can be considered as a collection of different approaches to management, sees organizational control as "*…a mechanism of strategy implementation*"[37]. Control is exercised in order to align the divergent interests of individuals within the organization. Control thus ensures that the self-interest of organization members is minimized on behalf of organizational interests. Anthony has defined management control as "*…a process by which managers influence other members of the organization to implement the organization's strategies*"[38]. Anthony distinguishes management control from strategic planning and task control. However, these concepts are hierarchically interrelated since task control is implemented according to the decision rules derived from management control, and management control aims at ensuring the achievement of the goals defined in strategic planning.

Simons, in turn, discusses management control systems as "*…the formal, information-based routines and procedures managers use to maintain or alter patterns in organizational activities*"[39]. Simons emphasizes that the competitive pressure created by management is a catalyst for innovation and adaptation. Thus traditional command-type, top-down-oriented control is no longer sufficient. In addition to the top-down information flows and commands that inform lower level employees about the organization's intended strategies, there need to be channels transferring information from the bottom of the hierarchy to the top. Through these channels top management receive information on the progress in achieving the intended strategies and also information on the threats and opportunities that may contain the seeds of new emergent strategies.[40]

The management of an organization tries to implement control for several important reasons: to ensure strategy implementation, to prevent the dysfunctional behavior of

[36] Simons 1995
[37] Hatch 1997 p. 327
[38] Anthony 1988 p. 10
[39] Simons 1995 p. 5
[40] Simons 1995

employees, to enable coordination, to provide a focus, and to enable reporting. First, the purpose of management control is to ensure that the organization implements its strategies effectively and to ensure the achievement of its long-term objectives[41]. Previous studies that differentiate strategy formulation from strategy implementation especially emphasize the assurance of strategy implementation as the main task of management control[42]. In the NPD context this is important, as earlier studies have shown weak linkages between NPD projects and business strategy[43].

Second, control is used to prevent the dysfunctional behavior of employees. Dysfunctional behavior can take several forms, such as the manipulation of performance measures or invalid reporting[44]. By controlling employees, management harnesses the self-interest of employees and ensures that the goals important to the organization are achieved[45]. An organization can be viewed as a coalition of members with different and often conflicting goals that can never be completely settled[46]. Management tries to measure and reward individuals in such a way that their possible self-interest also contributes to the goals of the organization[47]. The possibility of dysfunctional behavior is the main focus of control studies based on agency theory in which contracts are used to solve problems of potential divergent interests of agents (employees) and principals (organization)[48]. Contracts aim to specify performance measures and rewards in such a way that agents also serve their own interests when fulfilling the broader objectives of the organization[49]. In addition to deliberately pursuing self-interest, there might be some personal limitations that prohibit employees from working on behalf of the organization's best interest. Employees may not understand what is expected of them or the best way to perform certain tasks, for example due to a lack of proper training or a lack of accurate information[50]. In the NPD context, the technology-focused mindset of R&D employees may lead to the

[41] Anthony 1988, Otley and Berry 1980, Ouchi 1979
[42] See e.g. Anthony 1988
[43] Hertenstein and Platt 2000, Poskela 2007
[44] Jaworski 1988
[45] Simons 1995, Eisenhardt 1985, Merchant 1982
[46] Cyert and March 1963
[47] Eisenhardt 1985
[48] Eisenhardt 1989, Hatch 1997
[49] Ibid.
[50] Merchant 1982

development of technologically sophisticated products that do not necessarily have enough business potential from the company's point of view[51].

Third, without control there cannot be any coordination. Efficient control enables the coordination and integration of diverse activities and interests that are executed in different parts of the organization[52]. Lack of coordination leads to overlapping and inefficient resource usage, eventually decreasing organizational performance. This is especially evident in the NPD context as product development is essentially a cross-functional and dispersed effort involving different functions and expertise both inside the organization as well as outside with collaboration partners.

Fourth, management control can be used as a tool for systematically narrowing down the wide number of business opportunities so that the organization has a coherent set of activities directed toward the same purpose[53]. Management control is a critical activity in the front end of innovation, where opportunities are basically unlimited, in defining and selecting the new product concepts that will be developed further. Fifth, management control, e.g. in the form of performance measurement, also serves the reporting requirements that different internal and external stakeholders of the organization necessitate[54]. The existence of management control may also result from managers' individual psychological needs. Being in charge and taking responsibility for a certain business area or function may lead managers to use control procedures to give the feeling of security and confidence, even though the procedures cannot necessarily be justified from a rational management point of view.

2.1.1 Development of management control theory

Knowledge of the development of management control is important in interpreting the current theoretical body of knowledge and in understanding its potential future directions[55]. Table 1 summarizes the development steps in management control theory. The first column shows four development steps and the second column illustrates the prevailing organization paradigm, i.e. how employees of an

[51] See e.g. Smith and Reinertsen 1998
[52] Anthony 1988, Otley and Berry 1980
[53] Lorange and Morton 1974
[54] Lawler and Rhode 1976
[55] For excellent reviews of development of management control, see Otley et al. 1995, Hales 1993, and Barley and Kunda 1992

organization are perceived and how organizations are perceived to relate to their environment. Theorists dealing with organizations in a vacuum and separate from their environment view them as closed systems. On the other hand, organizations with continuous interaction with their environment exist in an open system domain. Rational models regard organizations as purposefully designed, goal-seeking entities, whereas unplanned, emerging and informal activities are the core of natural systems.[56] The third column shows management theories typical to the development step in question. The fourth column illustrates the management control focal areas for each particular step.

Table 1. Development steps of management control theory.

Development step	Prevailing organization paradigm	Management theories	Management control focus
Rational closed system perspective	Employees are rational actors. Organizations work in a vacuum separate from their environment.	Classical management theory: Taylorism, Bureaucracy, Cybernetics	Special and centralized controlling departments exist. Impersonal and formal process control are favored. Cybernetic ideas are seen as the ideal type of control.
Natural closed system perspective	Employees are social beings with diverse needs. Organizations work in a vacuum separate from their environment.	Human relations movement	Leadership is emphasized instead of management. Peer, self and informal modes of control are emphasized.
Rational open system perspective	Employees are rational actors. Organizations work in continuous interaction with their environment.	Systems thinking, Contingency theory	A full array of different control modes are used: input, process, output, value, informal, interactive, self and peer control.
Natural open system perspective	Employees are social beings with diverse needs. Organizations work in continuous interaction with their environment.	Postmodern, critical perspectives	Meaningfulness and justification of management control is questioned.

The foundation for formal process control was formed within the rational closed system paradigm based on principles of Taylorism[57], Fayol's[58] thoughts on the key functions of management, and later Weber's[59] ideas of "ideal bureaucracy". The focus of control was directed toward work processes that were governed by several rules, job descriptions and work procedure manuals. Control was characterized by strict formality and impersonality since the authority for control was based on the administrative system itself, with no room for individual considerations or interaction[60]. Effective control required the objective on which choices of action were based, the possibility and means for measuring results, a predictive model that

[56] Classification is based on Scott 1981
[57] Taylor 1911
[58] Fayol 1949
[59] Weber 1964
[60] Barker 1993, Hales 1993

connected inputs and outputs, and alternative options for the controller to consider[61]. These cybernetic[62] ideas of an ideal type of control system are still alive in modern management control, especially in routine types of activities, providing a foundation for defining work processes and controlling work activities.

The natural closed system perspective developed mainly because of increasing interest in the behavioral consequences of the control systems created in the previous era[63]. Narrow-focused, rule-governed and specialized jobs with low autonomy resulted in low job satisfaction, low commitment and a high turnover of labor, as well as inflexibility. According to the new "human relations" movement[64], employees were regarded as social beings with a need for acceptance, group affiliation and social interaction. Effective management was considered as being closer to leadership than pure scientific management[65]. Work tasks were recombined into broader, more meaningful entities and employees were given more responsibility in planning and controlling their activities in order to increase their motivation and commitment[66]. This was the starting point for controlling employees with softer control modes and admitting employees' capability for self and peer control.

Inflexibility, the slow responsiveness to environmental changes, and an increase in white-collar employees caused the shift to the rational open system era[67]. Decentralization was a key issue, with the aim of making managerial work more flexible and performance-oriented and making the organization as a whole more responsive to changing environmental conditions. The principles of systems thinking and analysis[68] and contingency theory[69] led to modeling organizations as systems and thinking within a specific management context to define the most efficient way of organizing activities. From the management control point of view, decentralization meant that the responsibility for control was partly transferred to those carrying the professional work itself. The full array of available management control modes was applied. Management control focused on inputs, outputs or processes, as well as on

[61] Tocher 1970, Hofstede 1978
[62] Ashby 1956
[63] Otley et al. 1995
[64] Mayo 1933
[65] Barley and Kunda 1992
[66] Hales 1993
[67] Barley and Kunda 1992, Hales 1993
[68] von Bertalanffy 1969, Gharajedaghi 1999, Checkland 1999
[69] Burns and Stalker 1961, Thompson 1967, Lawrence and Lorch 1967, Galbraith 1973, Chandler 1972

the basic beliefs existing in the organization. Softer self and peer control phenomena were used to complement external control. In addition, personal and informal management control mechanisms were used to fulfill specific situational demands. It is at this stage that management control theory still generally finds itself today.

The natural open system perspective brings more recent, critical thoughts on management control[70]. These ideas concern e.g. the political nature of organizational power and management control, questioning the justification and meaningfulness of one party having power and control over others[71].

This study adopts a broad perspective on management control. Organizations are perceived as being both rational and natural entities[72]. In addition, organizations are considered as operating in a highly dynamic business environment with continuous interaction with different stakeholders. Thus, several forms of management control mechanisms are studied here.

2.1.2 Management control frameworks

The existing literature provides several different categorizations of management control. Some kind of categorization is certainly needed to provide clarity and a platform for discussion based on common terminology. This chapter shortly introduces four often cited management control frameworks by Ouchi[73], Eisenhardt[74], Simons[75] and Hales[76]. The categorizations of these four control frameworks are further discussed in association with other models found in the literature.

Ouchi created the management control framework "Markets, Bureaucracies and Clans", which remains one of the hallmarks in management control literature today[77]. In market control, prices include all the necessary information to make effective management decisions reflecting the ideas of frictionless markets[78]. Competition is

[70] E.g. Chua et al. 1989
[71] Otley et al. 1995
[72] Thompson 1967
[73] Ouchi 1979
[74] Eisenhardt 1985
[75] Simons 1994
[76] Hales 1993
[77] Ouchi 1979
[78] Ibid.

the key for effective market control, ensuring that prices reflect the actual value of outputs and that profits reflect the accurate assessment of activity performance[79]. Market control is close to the ideas presented in transaction cost economics theory[80].

Bureaucratic control is based on the close monitoring and direction of subordinates through procedures and rules reflecting the ideas of Weberian bureaucracy. It can happen either by controlling behavior or output. Ouchi classified behavioral control as appropriate when task programmability is high but outcome measurability is low. Outcome control then fits situations where outcome measurability is high and task programmability is imperfect. When task programmability is perfect and outcome measurability is high, the organization has the option to use either behavioral or outcome control and can choose the control mode which is the most cost efficient.[81]

Clan control, in turn, is based on the ideas of shared and internalized cultural values, norms and expectations that guide the work of employees. The essence of clan control is that all members of an organization should have an implicit understanding of the values and beliefs that define the limits of appropriate behavior within the organization.[82] The controlling effect of clan control is based on the strategy to select and promote those individuals whose values are in line with the established values of top management. One potential disadvantage of this kind of opinion alignment could be an overemphasized consensus which decreases organizational innovativeness[83]. Even though the theoretical model created by Ouchi has laid a solid foundation for studying management control in organizations, it still offers quite a rough level of categorization of the different types of management control.

Eisenhardt[84] continued the work of Ouchi and combined organizational and economic aspects to provide a more holistic perspective on management control. She summarizes the basic strategies to design control in organizations. One approach is to define simple, routine jobs that can be easily observed and rewarded respectively. The second option is to design more complex job content and invest in information

[79] Daft and Macintosh 1984
[80] Williamsson 1975
[81] Ouchi 1979
[82] Ibid.
[83] Hatch 1997
[84] Eisenhardt 1985

systems that provide information on behavior that can be used to reward accomplishments. A third alternative is to design complex and interesting jobs, and use simple outcome-based evaluation and rewarding systems. The situation where task programmability is imperfect and outcome measurability is low leads to the fourth alternative which, according to Eisenhardt, is to emphasize the human resource management side and to focus on the selection, training and socialization of employees. Thus, instead of emphasizing the performance evaluation of employees, the organization can focus on selecting employees whose preferences coincide with those of the management.[85] Eisenhardt's contribution shows that management control does not exist without costs, and that these costs depend on organizational design.

Simons[86] studied control mechanisms and their association in strategic renewal. Simons defines four types of management control systems: belief systems, boundary systems, diagnostic control systems, and interactive controls systems. Belief systems are used to inspire and direct the search of new business opportunities and to define and communicate basic values, purpose and the direction for the organization. Strategy is considered as a perspective or collective mind. Boundary systems are used to set explicit limits and rules for opportunity-seeking behavior. Boundary systems define risks that must be avoided and deals strategy as a position setting boundaries for the strategic arena. Diagnostic control systems refer to traditional bureaucratic control which is used to set goals, monitor achievement and reward the achievement of specified goals. Strategy is seen as a plan defined at the top of the hierarchy. Interactive control systems refer to the management's personal involvement in the decision-making activities of subordinates. Interactive control is typically used to search strategic uncertainties and stimulate organizational learning. Strategy is seen, not as a plan, but as patterns of streams of actions. Furthermore, Simons emphasizes that effective strategic management requires a balance among these four levers of control.[87] Simons's contribution has been to link management control categories to different conceptions of strategy and to show how different management control mechanisms can serve different strategic purposes.

[85] Ibid.
[86] Simons 1994
[87] Ibid.

Hales has contributed to management control theory by clearly differentiating the focus of control from the style of using control, thus increasing understanding of how different types of control relate to each other[88]. He has considered management control in the context of the management's actual work activities and has defined four dimensions of control: 1) focus of control, 2) level of formality of control, 3) level of interactiveness of control, and 4) locus of authority of exercising control. The first dimension, the focus of control, categorizes management control by placing control practices in a chronological order based on the actual sequence in which the control is implemented. This leads to the following categories of management control: input, process, output, and value. Input control occurs before the controlled activity. Inputs, materials, and the knowledge and skills of those carrying out the forthcoming work are the main objects of this control. Process control, in turn, is exercised during the activity focusing on work processes and technical work methods of the controlled employees. Output control takes place after the activity and focuses on outputs, material, information, or financial results. Finally, value control influences the activities at all points in time by affecting the planning, implementation, and evaluation of work activities. Value control is a kind of meta control, which is based on the influence of the beliefs and norms of the company.[89]

Second, management control is classified in formal and informal ways of implementing control[90]. Jaworski has emphasized that formal control is typically written and management initiated, whereas informal control is unwritten and employee initiated[91]. However, informal control can be initiated by management as discussed by e.g. Davila[92] when the management decides, for example, to trust informal communication over a formal and defined reporting system. Many of the different control mechanisms can be applied either informally or formally. Thus the level of formality can be seen as a separate dimension of control rather than an individual control category[93].

[88] Hales 1993
[89] Ibid.
[90] Ibid.
[91] Jaworski 1988
[92] Davila 2000
[93] Hales 1993

Management control can be applied either in interactive/personal or bureaucratic/impersonal ways (third dimension)[94]. Interactive control means that managers have personal contact with the decision-making activities of their subordinates[95]. Hales emphasizes that personal control manifests in control exercised by one individual over others, whereas impersonal control is based on rules and regulations[96].

The locus of responsibility for implementing the control may also be possessed by different parties within the organization (fourth dimension)[97]. The control may rest in the hands of individuals (self-control), a group of colleagues (mutual or peer control), or a body which is separated from the work process itself (external control)[98]. The latter case refers to traditional, top-down implemented control.

Besides the abovementioned control categories, different forms of control can be classified, for example, into objective vs. subjective control, short-term vs. long-term control, or tight vs. loose control[99]. Basically every type of organizational control can be tightened by taking a more rigid approach to the use of a certain control or by using several different types of control simultaneously. Different management control types and management control mechanisms obviously have overlapping characteristics. In reality, the management selects a set of control mechanisms that complements each other and provides adequate control over work activities. The purpose is to achieve an appropriate level of control with the lowest cost possible, while still maintaining the employees' feeling of autonomy[100].

The literature analysis indicates that Hales's classification is the most thorough categorization of management control and it enables the synthesis of other frameworks found in the literature. The management control framework developed by Hales is thus adopted here in this thesis and is used as a theoretical management control framework. Table 2 shows the management control content of some selected

[94] Ibid.
[95] Simons 1994
[96] Hales 1993
[97] Ibid.
[98] Ibid.
[99] Fisher 1995
[100] Merchant 1982

and often cited authors. Ten management control models from different authors are included in the table, which shows the original concepts used by the authors and the classification of these concepts under eight control categories as according to Hales[101]. It is acknowledged that the division is somewhat arbitrary since the categorization of different types of control is both blurred and overlapping due to inconsistent terminology. For example, the term "value control" used by Hales[102] is close to the "belief control" categories used by Simons[103] and Marginson[104], but only partly covers "cultural control" as discussed by Jaworski[105]. The term "input control" which is used by Jaworski[106] and Hales[107] partly covers the "personnel control" used by Merchant[108] and Abernethy and Brownell[109]. In addition, the term "boundary control" used by Simons[110] fits into the input control category since it is used to set broad boundaries before the activity is executed.

Table 2. Management control models in the literature.

	Ouchi 1979	Merchant 1982	Eisenhardt 1985	Jaworski 1988	Hales 1993	Simons 1994	Ramaswami 1996	Abernethy and Brownell 1997	Bonner et al. 2002	Marginson 2002
input		x		x	x	x		x		
output	x	x	x	x	x	x	x	x	x	x
process	x	x	x	x	x	x	x	x	x	x
values				x	x	x				x
clan	x	x		x	x	x	x	x		x
self		x		x	x		x			
informal				x	x		x			
interactive					x	x	x		x	
	Market, bureaucratic and clan	Action, result and personnel	Behavior and outcome	Input, output, process, self, social and cultural	Input, output, process, values	Belief, boundary, diagnostic and interactive	Output, process, professional and self	Accounting, behavior and personnel	Process, output, rewarding, interactive	Belief, boundary, administrative and performance

The different control categories illustrated in the first column of Table 2 give a broad perspective on the different forms of management control. The following chapters discuss in detail these control types and single control mechanisms under these types.

[101] Hales 1993. The categorization is based on the fact that the main line of literature treats management control as management-oriented, formal and bureaucratic/impersonal. Thus Table 2 includes categories of "clan" and "self" but not management. It also includes the categories "informal" and "interactive" but not formal and bureaucratic/impersonal.
[102] Ibid.
[103] Simons 1994
[104] Marginson 2002
[105] Jaworski 1988
[106] Ibid.
[107] Hales 1993
[108] Merchant 1982
[109] Abernethy and Brownell 1997
[110] Simons 1994

The purpose is to give the reader a better understanding of alternative possible control mechanisms and the control mechanisms investigated in this study.

2.1.3 Input control

Several critical management control activities can be carried out far before any work activities are actually up and running. For example, it has been argued that there are basically two ways of achieving effective control within an organization; either to carefully search for and select the right people that fit the needs of the organization, or just to hire people and invest in establishing a managerial system which will instruct, monitor and evaluate employees[111]. The first alternative refers to human resource management, which is one critical part of input control. Input control focuses on preconditions, e.g. the knowledge, skills and motives of employees for successful task execution[112]. Input control encompasses different control mechanisms such as recruiting and resource allocation, strategic plans, task definition and boundary setting.

Merchant discusses personnel control, which can take several forms: 1) improving the capabilities of key persons through the tightening of hiring policies, training programs or more accurate job assignments; 2) improving communication channels so that employees better understand the content of their role and how their role fits into the larger framework of the organization; and 3) encouraging the peer type of control by forming cohesive work groups with shared goals.[113] The selection of the right person in the right job is an essential part of the management control process[114]. In the R&D context, personnel control refers to selecting the right team members and especially the right team leader for a particular development project[115]. Middle management project leaders have a critical strategic role in serving as a direct information channel to top management and translating top management's vision into concrete team activities[116]. Personnel control also provides the means to facilitate self and group control processes[117].

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[111] Ouchi 1979
[112] Snell 1992
[113] Merchant 1982
[114] Anthony 1988
[115] See e.g. McGrath 1996, Nonaka 1988, Smith and Reinertsen 1998
[116] Nonaka 1988
[117] Abernethy and Brownell 1997

Besides controlling human resources, access to financial resources is used as an input control mechanism. Control of financial resources refers to traditional budget control, which is intensively discussed in the literature[118]. Expenditure budget control is also important in the NPD project planning phase because the budget defines the scope of the task in monetary units and thus guides management decisions[119]. Schedules and deadlines have also been suggested in controlling NPD[120].

Strategic plans form an overall framework that is used to direct operative-level activities. A strategy can inspire innovations and define the framework within which the innovations must be kept without wasting resources on unwanted innovations[121]. One serious problem with NPD projects is often their weak linkage to the company's strategies. Wheelwright and Clark have argued that there is a need for a process that connects individual projects to the broader strategy of the company. They further argue that development projects need to have their own specific project strategy that fits within the broader development strategy.[122] While strategies define a broad framework for the tasks under execution, organizations can control activities by using specific task assignments that define expected activities more precisely[123]. Task assignments can be either formal or informal, and they basically define the management's expectations of the task's contribution to company-level goals. In addition, task assignments define detailed operative-level objectives for the team to achieve. Some authors have discussed the use of formal contract books between the project teams and management to define the goals of the task and the responsibilities of the team[124].

Management control is possible by defining the overall range of acceptable activities in the organization. Boundary systems, i.e., the formal ways in which management can set broad limits and rules for organizational activities, have been suggested as

[118] See e.g. Otley and Berry 1980, Rockness and Shields 1984, Rockness and Shields 1988
[119] Rockness and Shields 1988
[120] Lindkvist et al. 1998
[121] Sundbo 1996, Simons 1995
[122] Wheelwright and Clark 1992
[123] Merchant 1982, Bonner et al. 2002
[124] Davila 2000, Wheelwright and Clark 1992, Smith and Reinertsen 1998

effective input control in the literature[125]. The use of specific concept limitations to control and set limits on development activities early in the innovation process is a concrete example of boundary systems in the NPD context[126].

The applicability of input control in different situations is a relatively less researched area. Sometimes input control is examined as part of output control, where the goals and objectives (i.e. inputs) are considered only as reference points to reward (output control) work accomplishments. The overall impression is that input control fits many kinds of situations and should be used, at least to some extent, in all kinds of work activities. Rockness and Shields emphasize that input control is most important in situations where other types of control (e.g. process or output) cannot be used, i.e. in situations where there is no proper understanding of the transformation process or the expected outputs of activities[127]. It is reasonable to believe that input control has a critical role in the front end of innovation where process control or output control can have harmful effects on innovativeness. Personnel control in particular is often used and suits small organizations where the selection and training of key individuals can be the main type of control[128].

2.1.4 Process and output control

Process control and output control are at the core of any management control models and it is difficult to imagine any rationally and effectively working organization without either of these control types. Process control and output control are also the most often discussed control types in the literature[129]. In addition, process control and output control are often seen as alternative dominant forms of control in previous literature, and thus are discussed here together.

Process control focuses on work procedures and processes during the controlled activity, whereas output control focuses on the end results of a certain activity after the event. Merchant separates three basic types of process control[130]: 1) behavioral

[125] Simons 1994
[126] Ulrich and Eppinger 2003
[127] Rockness and Shields 1984
[128] Anthony 1988
[129] See e.g. Ouchi 1979, Merchant 1982, Eisenhardt 1985, Jaworski 1988, Hales 1993, Simons 1994, Ramaswami 1996, Abernethy and Brownell 1997, Bonner et al. 2002, Marginson 2002
[130] Merchant 1982. He uses the term "action" control.

constraints e.g. segregation of duties prohibiting improper activities; 2) action accountability including definitions of limits of appropriate behavior, monitoring activities, and rewarding or punishing deviations from the acceptable limits, and; 3) pre-action reviews in the form of direct supervision, formal planning reviews, or expenditure approvals[131]. Whereas the third type fits into the category of input control in this study, the first two types are examples of process control. In the case of complete process control, management holds employees responsible for following the established process guidelines and work instructions, but not responsible for the potential outcome of the specific activity[132].

The basic form of output control is to hold employees accountable only for the achieved results. Output control is close to the ideas of cybernetics mentioned earlier, which considers the function of control as a performance evaluation and feedback system that tries to eliminate uncertainty and to achieve perfect control over organizational activities. Control is induced to achieve the desired level of performance through the adjustment of activities. Goal-setting, measuring and monitoring compliance with targets, and giving feedback and rewards for actual performance are the basic managerial activities of cybernetic control[133]. Simons presents diagnostic control systems where formal incentives are linked to organizational output measures. This kind of incentive system allows people to capture the benefits of their own efforts, stimulating individual initiative and opportunity seeking. He further emphasizes that objectivity in measuring performance provides motivation and clear direction for employees.[134] Ouchi and Maguire have concluded that, quite paradoxically, output control is typically used when it is least appropriate, i.e. when complexity and interdependency of tasks are high or when there is a lack of expertise in the given task[135].

Process control is typically considered to be appropriate in situations of high task programmability and low outcome measurability, and output control in the opposite situation. When task programmability is perfect and output measurability is high, the

[131] Merchant 1982
[132] Jaworski 1988
[133] Hatch 1997, Joworski 1988, Merchant 1982
[134] Simons 1995
[135] Ouchi and Maguire 1975

organization typically chooses the most cost-efficient type of control.[136] Process control is typically preferred over output control if the means-ends relationships are known because of immediate control information[137]. Organizational size also influences the suitability of different types of control. According to Ouchi and Maguire, there is no need for output control in very small organizations if the premises for process control are fulfilled. Further, large organizations are forced to use output control because different organizational units must have usable measures for evaluating performance even when means-ends relationships would be understandable.[138] However, the motivational aspects favor using a certain type of output control (rewarding) even in very small organizations. An increase in task programmability, the possibility of behavior measurement, the cost of output measurement and output uncertainty typically lead to the favoring of process control[139]. A critical precondition for the use of process control is that the employees under control must know what kind of behavior is expected of them[140].

Several organizational factors influence the use of output control. The increase of complexity and interdependency of working tasks, company size, unfamiliarity with the technology involved in the task, and the position of hierarchical level in the organization increase the use of output control[141]. The position of hierarchical level can be explained through task complexity and interdependency. When proceeding at higher organizational levels, task complexity and interdependency increase. The knowledge of means-ends relationships is also less clear at higher organizational levels. In addition, the need for managers to defend their position, i.e. to show the performance of their department, causes the increased use of output control.[142] Merchant, in turn, states that the effectiveness and applicability of output control is significantly dependent on the overall rewarding structure that the organization uses[143].

[136] Ouchi 1979
[137] Ouchi and Maguire 1975
[138] Ibid.
[139] Eisenhardt 1985
[140] Merchant 1982
[141] Ouchi and Maguire 1975
[142] Ibid.
[143] Merchant 1982

The main process control mechanisms are different process models, standard operating procedures, and instructions and document templates to guide team members in their operative, daily activities. Formal process models and documentation enable the replication of process and also help management to improve the process when needed[144]. Other important process control mechanisms, especially in the NPD context, are the use of steering or management groups or special review points where initiatives are regularly monitored and decisions on whether the initiative should be continued or not are made[145]. Steering groups typically have the final responsibility of directing and confirming that development initiatives are proceeding in an appropriate direction. Periodic review points provide management an the opportunity (time and place) to give guidance on ongoing work without intervening or disturbing with hands-on intervention[146]. Organizational structure is another type of a process control mechanism[147], even though different opinions have also been expressed on this[148]. Organization structure facilitates the allocation of tasks and responsibilities, and the design of necessary systems ensuring effective communication and the integration of activities inside the organization[149]. From the management control point of view, organizational structure plays a significant role since it basically defines the lines of authority, roles and responsibilities, and especially that of formal reporting channels inside the organization. Several authors have discussed the use and importance of periodic or exception-based reporting for control purposes[150].

Some authors define specification and definition of performance objectives as a part of output control[151]. However, as the performance targets are defined before the activity, they are considered, by definition, input control mechanisms in this study. Defined objectives give direction and a reference point to employees to continuously make evaluations and decisions. These performance targets are indeed used

[144] Hertenstein and Platt 2000
[145] Cleland and King 1975, Comstock and Sjolseth 1999, Hertenstein and Platt 2000, Tatikonda and Rosenthal 2000, Englund and Graham 1999
[146] Tatikonda and Rosenthal 2000
[147] See e.g. Jaworski 1988
[148] See e.g. Flamholz et al. 1985
[149] Child 1977
[150] See e.g. Cleland and King 1975, Simons 1995, Abernethy and Brownell 1997, Hartmann and Vaassen 2003
[151] See e.g. Bonner et al. 2002, Ylinen 2004

afterwards, when the performance of employees is evaluated following the executed activity. In this context, performance targets are part of the rewarding system, which is the key output control mechanism. Rewarding is typically based on the use of some type of monetary incentive[152], but also non-monetary rewarding such as recognition has been noted to be an important tool for control purposes[153]. The basic idea is to set personal incentives for employees that are tied to the achievement of defined organizational objectives. Chester discusses the importance of having an overall rewarding system that reinforces values and behaviors that maximize R&D's contributions to the company's strategies[154]. Further, Chester lists four main types of incentives for the R&D work: individual incentive (monetary), team incentive (monetary), organizational incentive such as granting funds for a particular project, and non-monetary incentive[155]. Team-based rewarding in the NPD context has been emphasized recently in order to advance peer control pressure and to avoid problems related to the evaluation of individual achievement inside teams[156]. Furthermore, rewarding may be based on either an objective or subjective evaluation of performance depending on the characteristics of the specific task[157].

Another typical output control mechanism in the NPD context is the use of evaluation and selection criteria at different stages of NPD or in the front end phase. These criteria are used to evaluate the proficiency of ideas and concepts afterwards and to make decisions about how to proceed. In the front end phase there at least three stages where the selection criteria are normally applied to evaluate the output of the accomplished activity or sub-activity. The first stage is the initial selection which defines the opportunities the firm wants to pursue. Koen et al. give four criteria related to the strategy, market segment, competitors, and customers to quickly review identified opportunities[158]. This initial selection is followed by the idea screening and selection phase where the most potential and promising ideas are selected for further analysis. Several authors have listed helpful criteria for determining the usefulness

[152] See. e.g. Goold and Quinn 1990, Chester 1995
[153] Simons 1995, Chester 1995, Merchant 1985
[154] Chester 1995
[155] Ibid.
[156] Hertenstein and Platt 2000, Ouchi 1979, Chester 1995, Bonner et al. 2002
[157] Goold and Quinn 1990, Govindarajan and Fisher 1990, Simons 1990
[158] Koen et al. 2002

and feasibility of new product ideas[159]. The final selection point is at the end of the front end phase, when management critically evaluates the concepts before launching the formal product development project phase[160].

Creating and trusting competitive conditions is one option to use output control. Ouchi has discussed trusting free markets as this type of control mechanism[161]. Park, in turn, has considered "game-theoretic mechanisms" that exploit the competitive nature of some bargaining situations and contribute to promoting innovations[162]. Taking this idea, Rockness and Shields have emphasized the importance of studying the internal competition of project funding in the R&D context[163]. Essentially, these kinds of internal competition-based control can take two forms in the innovation management context, either focusing on competing product concepts[164] or competing development teams[165] building the solution for the same problem or opportunity. The approach of developing competing product concepts is often followed in car manufacturing and other consumer product industries[166]. Pich et al. have recommended this kind of "selectionism" to be used especially in the context of high ambiguity and complexity[167]. This enables the exploration of a larger amount of different available options, hedging against unanticipated events and having multiple product concepts available at the final selection point when the development projects are chosen.

2.1.5 Value control

Value control (belief or cultural control) refers to the use of different mechanisms that provide basic values, purpose and direction for the organization and its members. Value control is used in a positive sense to inspire, motivate and direct the search of new business opportunities[168]. Simons discusses formal belief systems, meaning the mechanisms that top management uses to define and communicate the basic values and overall direction for the organization. Simons's study gives important insights

[159] Cooper 1998, Anschuetz 1996, Bacon et al. 1994
[160] Wheelwright and Clark 1992
[161] Ouchi 1979
[162] Park 1998
[163] Rockness and Shields 1988
[164] Wheelwright and Clark 1992, Ulrich and Eppinger 2003
[165] Poskela 2006, Pich et al. 2002
[166] See e.g. Srinivasan et al. 1997, Sobek et al. 1999
[167] Pich et al. 2002
[168] Simons 1995

into using values and beliefs in formal ways. Credos and mission statements are examples of these formal documents which reinforce the common belief base of the organization.[169] The values reflect how top management understands the firm's overall strategic mission and vision of an ideal future[170]. Values and attitudes are deeply rooted in the organizational culture. The culture provides a sense of community with shared values, traditions and obligations[171] that contributes to normative patterns with the help of stories, rituals and the norms of social interaction[172], and that supports, as well as partly substitutes, other control mechanisms in the organization[173]. The importance of an innovation-favorable culture and values which support risk taking and experimentation and which appreciate innovations and an entrepreneurial attitude are widely acknowledged in the NPD context[174]. Cultural control is often considered to be a dominant form of control in work positions characterized by non-routine and non-programmable decision-making situations[175].

Even though value control is to some extent an informal type of control that materializes in the form of self and peer control, top management has many formal alternatives to affect organizational values. One way is to use mechanisms that communicate the company's mission and strategic vision throughout the organization[176]. The internalized mission and vision then guide members of the organization in their daily activities and decision-making situations. McGrath has listed the qualities of a good strategic vision as sufficiently focused; interpreted in the same way by everyone; complete including answers to questions such as where to go, how to get there and why this path leads to success; and feasible, i.e. attainable[177]. In addition, senior management's leadership is also an effective way to embed and

[169] Simons 1994
[170] Artto et al. 2004
[171] Stewart 2002, Merchant 1985
[172] Jaworski 1988
[173] Merchant 1985
[174] See e.g. Trott 2002, Zien and Buckler 1997, Sundbo 1996
[175] Jaworski 1988
[176] Simons 1995, Marginson 2002
[177] McGrath 2001

advance core values inside the organization[178]. Leadership provided by charismatic senior managers serves both to direct and to motivate subordinates in their work[179].

2.1.6 Informal vs. formal control

Formal and informal types of control should be used to complement the weaknesses of each other[180]. Formalization typically refers to the extent to which rules, procedures or instructions are written[181], and informality can be associated with situations characterized by behavioral spontaneity, casualness and interpersonal familiarity[182]. Typically, informal control has been related to the use of values as the main object of control, and formal control to the use of input, output or process as the main object of control[183]. However, the degree of formality can be seen as a distinct dimension of control. Input, output, process or value refers to the focus of control, i.e. the issue being controlled, and the level of formality can be associated with each type of these controls[184].

The literature provides several examples of how input, output and process control mechanisms have been used in an informal manner. Kirsch illustrates how information exchange happens through standard operating procedures and status reports under formal control, whereas informal control uses socialization, training and dialogue as mechanisms of information exchange. Rewarding, in turn, is based on following specified rules and achieving specified targets in formal control. In informal control, rewarding is based more on acting in a manner that is consistent with group values.[185] Other informal control mechanisms mentioned in the literature are, e.g. managerial observation and surveillance[186], informal visits and telephone conversations[187], dialogues and hallway chats[188] and ad hoc meetings[189]. Bisbe and Otley emphasize that both informal and formal control mechanisms are needed and

[178] Merchant 1985
[179] Mumford 2000
[180] See Kirsch 2004 for a good illustration of differences between formal and informal types of controls.
[181] See e.g. Pugh et al. 1968, Jaworski 1988, Langfield-Smith 1997
[182] Morand 1995
[183] See e.g. Jaworski 1988, Ramaswami 1996
[184] Hales 1993
[185] Kirsch 2004
[186] Ekanayake 2004, Anthony 1988
[187] Cleland and King 1975
[188] Merchant 1985, Anthony 1988
[189] Anthony 1988

should also be balanced in the product innovation context. Informal control mechanisms encourage and inspire new ideas, whereas formal control mechanisms help to ensure that new ideas are effectively transformed into product innovations.[190]

2.1.7 Self vs. peer vs. external control

The locus of responsibility in the implementation of control can vary inside the organization. For the sake of simplicity, the responsibility of implementing control is grouped here into three categories: self-control, peer control and external control[191]. The earlier discussion of the use of input, output and process controls emphasizes that there is some kind of external party, normally management, that implements control over employees by means of formal or informal control mechanisms. However, the locus of implementing control can also be at a group or individual level, where the influence of control is based more on informal and personal means of conducting control and also on the internalized values of the organization. Sometimes self and peer control are grouped under the term organizational control, emphasizing that they are not control types possessed by the management. However, since management has a deliberate choice to trust in and to nourish self or peer control behavior, these control types are also part of management control.

Peer control has been thoroughly investigated as a form of control, even though it is often discussed with inconsistent terminology[192]. According to Ouchi, clan (or peer) control refers to an informal social structure consisting of individuals with similar values[193]. It illustrates social perspectives and patterns of interpersonal interactions that are based on both the internalization of group values and the mutual commitment toward common goals[194]. It may differ from the cultural control discussed earlier which deals with cultural values in the whole organization and not at group level. Peer control means that group members themselves control and steer their own activities. The controlling effect comes from the social pressure to conform to group norms and values in order to work in an acceptable manner and to achieve common group goals. Hofstede calls this “political control”, meaning that decisions are often based on

[190] Bisbe and Otley 2004
[191] See. e.g. Ouchi 1979, Merchant 1982, Jaworski 1988, Hales 1993, Ramaswami 1996
[192] The other terms are e.g. clan control by Ouchi 1979, social control by Jaworski 1988, and professional control by Ramaswami 1996
[193] Ouchi 1979
[194] Jaworski 1988, Kirsch 1996

political negotiation and judgment[195]. Management can also have a role in instituting peer control, even though this tends to be related more to persons sharing an equal hierarchical position. As previously mentioned, peer group self-regulation can be enhanced by appropriate human resource selection procedures and placement policies[196], by forming particular work groups[197], or by educating employees in the appropriate values and norms of behavior[198]. In addition, managers can encourage people to monitor each other's work and behavior e.g. by using team-based rewarding, as already discussed. The emphasis of peer control does not necessarily mean that management loses or weakens its control of employees. Barker concludes that giving up decision-making authority to teams and using a powerful combination of peer pressure and rational rules can actually increase control and make the "iron cage" stronger[199].

Peer control necessitates shared values in order to be effective. Ouchi argues that peer control is the most demanding type of control (compared to market or bureaucratic types of control) because it requires a norm of reciprocity and shared beliefs. Ouchi concludes that this type of control especially fits situations of high ambiguity and uncertainty where the reliable and accurate measurement of activities is not possible.[200] O'Reilly and Tushman emphasize that when work tasks face increasing change, complexity and uncertainty, control systems cannot only be based on static and formal control mechanisms. Control must come in the form of social control systems that allow greater and direct autonomy, and rely on the judgment of employees informed by a clear strategic vision.[201] However, clan control is the most adaptable type of control, and thus suits many kinds of situations[202].

Individual self-control, if aligned with company goals, is the most powerful type of control. Barley and Kunda state that "*by winning the hearts and minds of the workforce, managers could achieve the most subtle of all forms of control: moral*

[195] Hofstede 1978
[196] Abernethy and Brownell 1997, Kirsch 1996, Hofstede 1978
[197] Merchant 1985
[198] Kirsch 1996, Ouchi 1979
[199] Barker 1993
[200] Ouchi 1979
[201] O'Reilly and Tushman 1997
[202] Merchant 1982

authority"[203]. This refers to the form of normative control where individuals take the responsibility of controlling their own activities[204] by managing their own behavior through setting personal goals, evaluating their performance based on these goals, and adjusting their behavior based on the results[205]. The use of self-control rests on the understanding that employees have an intrinsic motivation to do a good job and that they get self-satisfaction from doing their work and seeing that their company prospers[206]. The role of management is more consultative compared to other types of control and instead focuses on providing support and clear task boundaries for individuals[207]. Management can promote self-control by empowering employees, structuring work activities appropriately, training employees with appropriate self-controlling techniques, and using rewarding systems that value self-controlling behavior[208]. Self-control is also associated with peer control. Decreased supervision by management in the case of self-control leads also to increased peer consultation among employees[209].

The use of peer control and self-control would likely be suitable in the front end of innovation, which requires persistent effort to conceive new ideas and solve emerging problems in a very uncertain work context. Self-control is typically exercised in uncertain situations where the output measurability and knowledge of the transformation process is weak[210]. Thus it provides a substitute for the traditional process and output control approaches. Actually, self-control enables the elimination of many of the typical problems and challenges associated with traditional output and process types of control[211].

2.1.8 Interactive vs. bureaucratic control

Interactive control enables management to acquire accurate and reliable information, to challenge and motivate employees, and to promote vertical integration. Interactive

[203] Barley and Kunda 1992 p. 364
[204] See e.g. Mills 1983, Manz 1986, Jaworski 1988, Ramaswami 1996, Hales 1993 and Kirsch 1996. The term self-control is often used interchangeably with terms self regulation, self management and self influence.
[205] Manz and Sims 1980
[206] Merchant 1985
[207] Mills 1983
[208] Kirsch et al. 2002
[209] Mills 1983
[210] Mills 1983, Govindarajan 1988, Otley 1994
[211] Jaworski 1988

control means that some kind of personal interaction takes place between management and employees[212]. Bureaucratic control, in turn, refers to the use of impersonal means such as instructions or plans as a control mechanism. Many of the informal control mechanisms such as ad hoc meetings or phone calls are interactive control mechanisms. Simons argue that any diagnostic (traditional output or process) control system can be made interactive if the management takes an active role and involves itself, showing personal interest and commitment. The main purpose of making some control interactive is to focus the organization's attention and force dialogue and learning inside the organization.[213]

The use of interactive control mechanisms also makes the control more adaptable and convenient for employees, simultaneously decreasing the probability of dysfunctional behavior. One example of such mechanism is to provide employees with the possibility to participate in goal-setting activities and in defining the suitable procedures for achieving those goals. Participative goal-setting and task planning increases employees' understanding of the task's goals and the needed activities, and also gives both sides the same understanding of the forthcoming task. This further decreases the need for additional process control while motivating employees by encouraging them to feel like experts in their own work.[214] Bonner et al. conceptualize interactive control in the NPD context as the interaction between management and project members during the formulation of project strategies, goals and procedures early in the project[215]. The participation in strategy formulation can happen at a company level as well. Simons argues that even though managers draft strategic statements, they could also circulate drafts of strategies to middle managers for commenting and refining, thus enhancing the clear communication of strategic statements and strategic vision[216]. Further, interactive dialogue of strategic issues can be advanced e.g. by organizing face-to-face meetings between management and employees[217].

[212] See e.g. Hales 1993, Simons 1994, Ramaswami 1996, Bonner et al. 2002
[213] Simons 1994
[214] Ramaswami 1988
[215] Bonner et al. 2002
[216] Simons 1995
[217] Simons 1995, Simons 1991, Marginson 2002, Ylinen 2004

Management intervention refers to one type of interactive control; management's involvement in operative-level decision-making. Bonner et al. have discussed management intervention in the NPD context and have shown examples of such intervention, such as changing project goals midstream, imposing new procedures, influencing team decisions, or overriding decisions made by the team. They have further argued that management intervention may force the team to change its direction therefore making some accomplished tasks obsolete, and thus lengthening project completion and harming the team's morale.[218] Typically, management intervention has a negative influence on team innovativeness and performance[219].

Interactive control mechanisms stimulate experimentation and opportunity seeking and thus give input for innovations and the formation of emergent strategies. They also provide a forum for face-to-face discussion and debate for collectively making sense of new opportunities. Thus interactive control mechanisms are especially suitable in constantly changing business environments.[220]

2.2 Management control in new product development

There are many influential studies that have increased the current understanding of management control in the NPD context. Some of these articles include qualitative case studies[221] focusing on detailed descriptions of management control in a few cases and others are quantitative survey studies[222] that have taken larger samples and tried to test different management control hypotheses. While some of these studies have only explored the suitability of different control mechanisms in different tasks, organizations or environmental contexts, some have tried to find a more profound correlation between the use of certain control mechanisms and performance. Table 3 summarizes these influential management control studies carried out in the NPD context. The research method, the empirical data and the main findings are highlighted in relation to each study.

[218] Bonner et al. 2002
[219] Olson et al. 1995, Bonner et al. 2002, Gerwin and Moffat 1997
[220] Bisbe and Otley 2004
[221] E.g. Abernethy and Brownell 1997, Nixon 1998, Davila 2000, Hertenstein and Platt 2000
[222] E.g. Rockness and Shields 1984, Rockness and Shields 1988, Abernethy and Brownell 1997, Davila 2000, Hertenstein and Platt 2000, Bonner et al. 2002, Ylinen 2004

Table 3. Management control studies in the NPD context.

Authors	Empirical data	Research method	Research findings
Rockness and Shields 1984	10 organizations from USA. 76 responses from first-line R&D supervisors.	Survey study. Input, output and process control were covered.	Input control mechanisms are important when there is little knowledge of the transformation process. Process controls are important when high knowledge of the transformation process prevails. Importance of control mechanisms is not dependent on the measurability of the work group's output, task complexity or task dependence.
Rockness and Shields 1988	10 organizations from USA. 76 responses from first-line R&D supervisors.	Survey study. Expenditure budget control and social control were covered.	The importance of expenditure budget control is positively associated with work group size, budget size and the external source of R&D funds. There is negative association between the perceived importance of social control and expenditure budget control.
Hertenstein and Platt 2000	75 industrial design managers.	Interviews, workshops, survey study. Position of NPD in the organization, the NPD process model, and performance measurement were covered.	The need to integrate NPD and strategy more explicitly has led to NPD managers reporting higher up in the organization, thus allowing them to better participate in strategy formulation. NPD processess have been linked more explicitly into strategy. The link between performance measurement and the strategy was weak.
Nixon 1988	In-depth case study in a single firm	Interviews. Accounting-based control covered.	Accounting-based control has an important role in the evaluation of different design alternatives.
Davila 2000	Seven case study companies (12 business units). Survey study of 56 project managers.	Interviews of project managers, marketing managers, R&D managers and general managers. Different control mechanisms of a project manager were covered.	Project managers' intense use of control mechanisms led to improved project performance.There is a positive linkage between the detailed definition of project objectives and project performance.
Abernethy and Brownell 1997	Two companies studied. 127 responses from senior research officers.	Survey study and interviews. Accounting, process and personnel control vere covered.	Under high task uncertainty, personnel control is positively related to high performance. Under low task uncertainty, accounting control has a positive influence on performance. Personnel control is suitable over accounting or behavioral control in tasks including the high number of exceptions. Process control does not contribute positively to performance in any circumstances.
Henderson and Lee 1992	48 I/S design planning teams from 10 companies. 310 responses.	Survey study. Process, output and self-control were covered.	Process control is positively associated with a design team's performance. Team members' outcome control had a strong positive association with team performance. The hypothesis that the self-control of team members would lead to team performance was marginally supported.
Kirsch 1996	17 companies and 32 systems development projects. 96 responses.	Survey study. Process, output, clan and self-control were covered.	Improved behavior observability and improved controller's knowledge of transformation process leads to using process control. Low output measurability leads to relying on self-control behavior. The amount of self-control does not increase as behavior observability decreases.
Kirsch 2004	Two case studies.	Interviews and document analysis. Several formal and informal process and output control mechanisms were covered.	Formality took place instead of informal and subjective control mechanisms when the initiative proceeded from the requirements definition phase onwards.
Bonner et al. 2002	95 responses from USA-based companies.	Survey study. Process control, output control, team rewards, team operational control influence, team strategic control influence, and management intervention were covered.	Process control and management intervention have a negative effect on project performance. Interactive setting of operational goals and process procedures for evaluating and monitoring the project is positively associated with the project performance.
Ylinen 2004	114 responses from technical and administrative development projects.	Survey study. Interactive and diagnostic use of project feedback and measurement systems were covered.	Interactive use of management control mechanisms leads to greater product innovativeness and further improved project performance.

Rockness and Shields investigated control mechanisms through questionnaires applying the control framework of Ouchi[223] and measured input, output and behavioral control mechanisms[224]. The findings indicated that the importance of control mechanisms is associated with knowledge of the task transformation process. Input control mechanisms (social control and expenditure budgets) are important when there is little knowledge of the transformation process. Process controls (rules,

[223] Ouchi 1979
[224] Rockness and Shields 1984

procedures, PERT), in turn, are important when high knowledge prevails. The results indicated that the importance of control mechanisms is not, however, dependent on the measurability of the work group's output, task complexity or task dependence.[225]

In their follow-up article, Rockness and Shields investigated the use of budget control, namely expenditure budgets in R&D work groups[226]. Rockness and Shields again applied Ouchi's[227] framework and located R&D in the category of low output measurability and low knowledge of the input-output transformation process. The results indicated that the importance of expenditure budget control is positively associated with some contextual variables, namely work group size, budget size and the external source of R&D funds. The results also showed the negative association between the perceived importance of social control and expenditure budget control.[228] Both articles of Rockness and Shields[229] describe the contextual suitability of control mechanisms, but do not make any claims of the linkage between the use of control mechanisms and organizational performance. However, they give some indications that input control may have an important role in the front end of innovation, whereas process control may be difficult to apply due to the fuzziness of the transformation process of embryonic ideas into product concepts.

Hertenstein and Platt investigated the work of design managers and focused on three management control mechanisms, namely the position of NPD in the organization, the NPD process model, and performance measurement[230]. They found that the need to link NPD and strategy more explicitly has led to NPD managers reporting higher up in the organization, thus allowing them to participate in strategy formulation. In addition, many of the investigated organizations have recently revised and formalized the NPD process, adding explicit steps to link NPD projects to the strategy of the organization. Finally, they found that the link between performance measurement and the strategy was often weak in the investigated companies. Hertenstein and Platt concluded that increasing recognition of the fact that strategy and NPD must be integrated, as well as of the importance of NPD in strategy implementation in general,

[225] Ibid.
[226] Rockness and Shields 1988
[227] Ouchi 1979
[228] Rockness and Shields 1988
[229] Rockness and Shields 1984 and 1988
[230] Hertenstein and Platt 2000

has led to changes in management control mechanisms in order to increase the use of strategy-related information in NPD decision-making.[231] Hertenstein and Platt's study emphasized the importance of integrating strategic decision-making into the NPD process. The appropriate use of different management control mechanisms in the front end of innovation enables management's involvement in decision-making when strategic choices related to product concepts are made.

Nixon conducted an in-depth case study in a small company and showed the importance of accounting-based control, i.e. the use of target costing and other financial techniques, in the evaluation of different design alternatives. A financial controller had an important role in assisting engineers and balancing different design requirements in the investigated case company.[232] Unlike typical studies that consider performance as more of a dimension of goal concurrence, Davila provided a good description of management control mechanisms as a tool to deal with information uncertainty. The results indicated that the project manager's intense use of control mechanisms led to improved project performance. In addition, he found a positive association between the detailed definition of project objectives and project performance.[233] Davila's work, though based on the project manager's control mechanisms, indicated that control mechanisms, especially input control mechanisms, are positively associated with performance.

Abernethy and Brownell applied Perrow's[234] well-known model of technology and structure with the purpose of explaining how task characteristics (task analyzability and number of exceptions) influence the effectiveness of accounting, behavior and personnel control mechanisms[235]. In situations where the task uncertainty is highest (i.e. task analyzability is low and the number of exceptions is high), of these three control types personnel control is significantly and positively related to high performance. Conversely, accounting control has a significant positive influence on performance in situations where task uncertainty is the lowest. In tasks where the number of exceptions is high, personnel control is suitable over accounting or

[231] Ibid.
[232] Nixon 1988
[233] Davila 2000
[234] Perrow 1967
[235] Abernethy and Brownell 1997

behavioral control. Finally, Abernethy and Brownell conclude that process control does not contribute positively to performance in any circumstances.[236] While providing a serious attempt of linking the use of control mechanisms and organizational performance, as well as completing the work of Rockness and Shields[237], the study had some weaknesses that should have been taken into account. For example, the measurement of personnel control was based on only a single item proxy measure. However, the results indicated that the main contingency variable, i.e. task uncertainty, may have had a major influence on the applicability of different management control mechanisms. Based on these results, it can be expected that market and technology uncertainty, which are the main components leading to task uncertainty in the NPD context, may have an impact on the relationship between the used management control mechanisms and front end performance.

Control research in information systems and information technology development projects gives valuable insight into the applicability of different control modes. Henderson and Lee showed that both strong managerial process control (exercised by a project manager) and high output control by the team coexisted. Process control provided means for aligning diverse and competing individual goals, whereas team members' output control gave flexibility to cope with inherent uncertainties of design activities. The results indicated that an increase in managerial behavior control is positively associated with design teams' performance. In addition, team members' outcome control had a strong positive association with team performance. However, Henderson and Lee found only marginal support that team members' increased self-control would lead to better team performance.[238] The findings show that different control mechanisms are used simultaneously and that companies may apply company-specific control strategies. Kirsch found that improved behavior observability and the controller's improved knowledge of the transformation process led to using behavior control. In addition, survey results indicated that unclear project outcomes, i.e. low outcome measurability, lead to relying on self-control behavior. Further, the results indicated that the amount of self-control does not increase as behavior observability decreases. Kirsch explains that self-control does not appear out of nowhere, but it

[236] Ibid.
[237] Rockness and Shields 1984, Rockness and Shields 1988
[238] Henderson and Lee 1992

needs to be promoted through the creation of an appropriate working environment, communicating the value of self-control behavior, and training employees in the appropriate techniques. In addition, the results suggested that the more familiar the controller is with the substance of information system development, the more likely that person is promoting self-control behavior. Finally, Kirsch concluded that self-control is an attractive alternative in non-routine and complex tasks.[239] Even though latter two studies investigated project managers' control mechanisms, they indicated that process control may have a positive influence on design performance and that the use of process control is dependent on behavior observability and the controller's own knowledge of the transformation process. In addition, the findings indicate that management seems to have an important role in promoting and instituting capabilities of self-control behavior.

In the other study, Kirsch showed that management control modes indeed change when a novel idea proceeds in the innovation process pipeline. Formality replaced informal and subjective mechanisms when the initiative proceeded from the requirements definition phase. Furthermore, Kirsch emphasizes the need for studies that would specifically examine an effective mix of different formal and informal control types.[240] Kirsch also makes the important point that managers exercise different control modes in order to achieve different outcome objectives, i.e. some control modes are more applicable for achieving certain types of objectives than others[241]. Importantly, Kirsch's findings question the relevancy of studies that deal with the innovation process as a whole without considering the management control mechanisms used separately in different phases.

Bonner et al. studied three formal control mechanisms (process control, output control, and team rewards) and three interactive control mechanisms (team operational control influence, team strategic control influence, and management intervention)[242]. The results showed that NPD teams need some control over the project objectives and procedures to be followed but senior management can also force too much and use the wrong type of control. Process control mechanisms were

[239] Kirsch 1996
[240] Kirsch 2004
[241] Kirsch 1996
[242] Bonner et al. 2002

noted to have a negative effect on project performance. The same phenomenon was seen in the situation where management intervened in teams' operative-level decision-making. In addition, interactive control mechanisms, i.e. team members' and senior management's shared involvement in setting operational goals and process procedures for evaluating and monitoring the project, were positively associated with the performance. Quite interestingly, no support was found for the hypothesis that product innovativeness moderates the relationship between the use of process or output control mechanisms and project performance. Finally, Bonner et al. emphasized that formal control mechanisms and their influence on development performance are still a superficially covered control area.[243] The findings of Bonner et al. offer two notable observations for this study. First, the result indicated that process control may have a negative influence on performance. Second, interactive control mechanisms (team operational control influence) had a positive influence on performance only in operative-level matters and not in strategic-level questions.

Ylinen focused on the effects of the interactive and diagnostic use of project feedback and measurement systems on project innovativeness and final project success[244]. He found that the interactive use of management control mechanisms led to greater product innovativeness which, in turn, led to improved project performance in technical development projects. However, the results did not indicate any negative relationship between the diagnostic use of management control mechanisms and project innovativeness.[245] Again, the findings show the importance of interactive control mechanisms.

While providing a good starting point for future research, these influential studies must be evaluated critically to understand their potential shortcomings. One such shortcoming[246] is that the studies spanned both the front end phase and the development project phase in the focus of the study, thus averaging the effect of e.g. uncertainty and complexity of performance[247]. As mentioned previously, because of the fundamentally different nature of these phases, each phase should probably be

[243] Ibid.
[244] Ylinen 2004
[245] Ibid.
[246] See Davila 2000 and Kirch 2004 for exceptions
[247] See Davila 2000 for a detailed discussion of this

managed differently[248]. More research is needed to understand the actual difference in the use of management control mechanisms in these phases.

The second issue is the limited scope of different control mechanisms included in the studies[249]. Typically, firms use a wide variety of control mechanisms for different purposes and also to compensate for the weaknesses of a certain mechanism. The selection of what to include and what not to is naturally done in the aim of getting manageable research designs and compromising between the scope of research and the level of detail. However, the possible bias of focusing on just a few control mechanisms at a time and ignoring the interactive effects of different control mechanisms should be noted.

Thirdly, different control mechanisms can be used in different manners, i.e. formal or informal ways, interactive or bureaucratic ways. The level of formality and interactivity may affect the suitability of control mechanisms in certain situations. The abovementioned studies[250] failed to investigate these dimensions of control mechanisms. Finally, some of these studies[251] focused on management control mechanisms from the project manager's point of view without considering those mechanisms used by senior management, which is the focus in this study. The mechanisms used and their applicability may differ depending on the organizational level and the purpose of control.

2.3 The front end of innovation

Inconsistent use of innovation terminology hinders theory development and makes it difficult for practitioners to interpret research findings. Thus the following paragraphs define the terms innovation and innovation process as used in this study.

The concept of innovation itself is complex and vague without a universally accepted definition[252]. The definition of innovation by the OECD[253] covers two central issues.

[248] Zien and Buckler 1997, Koen et al 2001, Nixon 1998, Rockness and Shields 1984
[249] See e.g. Rockness and Shields 1988, Hertenstein and Platt 2000
[250] See Bonner et al. 2002 and Ylinen 2004 for exceptions
[251] Henderson and Lee 1992, Kirsch 1996, Davila 2000
[252] See e.g. Garcia and Calantone 2002
[253] OECD 1991

Firstly, innovation emerges from a process starting with invention through development, production, market introduction, and finally ending with commercial success. Secondly, it is a question of an iterative process, meaning that innovation includes both the introduction of a new offering and later its incremental improvements.[254] Thus, the initial idea or scientific discovery, i.e. *invention,* turns into innovation after the process of development, production, and market introduction. Rogers gives the following definition of innovation: *"An innovation is an idea, practice, or project that is perceived as new by an individual or other unit of adoption"*[255]. The essence of this definition is to define a concept as 'new' from the point of view of the unit that is dealing with the innovation. In the NPD context this microeconomic viewpoint of newness is of importance. While developing a new product, a firm faces the challenge of developing new technological solutions, market understanding, needed competences and skills. This may require a firm rejecting existing information, competencies or solutions in order to be capable of bringing new products onto the market.

Innovation in this dissertation is defined as *the introduction of a new product to the market place*[256]. The term 'new' is defined from the viewpoint of the organization developing the idea. The term 'marketplace' can refer to either internal or external markets. In the case of internal markets, the innovation deals with organizational innovations related to e.g. work process or management techniques. In this thesis, the focus is on product innovations that are sold to external markets. Innovation can be a failure or success. Unsuccessful innovation is a commercialized idea that does not achieve the defined efficiency or profit targets. A successful innovation achieves or even exceeds defined targets, enabling a developing firm to take advantage of their investments in development.

The term *product innovation* refers here to an innovation which has a tangible entity as its core value creation mechanism. It is well understood that product innovations may be associated with service components on many occasions. Wheelwright and Clark have presented an often cited classification and made the distinction between

[254] Garcia and Calantone 2002
[255] Rogers 2003, p. 12
[256] Adopted from O'Connor et al. 2008 p. xxii

derivative, platform, and breakthrough projects in the product innovation context. Derivative projects relate to improving, upgrading or extending existing products and pursuing short-term benefits. In breakthrough projects, both the new core product and process are developed in order to build long-term competitive advantage. Platform projects fall between derivative and breakthrough projects in their newness. In addition, Wheelwright and Clark identify development projects as focusing on R&D, which are a precursor to commercial development, and alliances and partnerships, which can be commercial or basic research-driven activities[257].

The division between derivative, platform, and breakthrough relates to the classification of projects based on the newness of the developed product. A thorough synthesis for innovations in relation to their newness, or radicalness, is provided by Garcia and Calantone, who have divided innovations into incremental, really new, and radical. Radical innovations are innovations that cause marketing and technological discontinuities on both a macro (world, industry or market) and micro (company or consumer) level. Incremental innovations occur only at a micro level and cause either a marketing or technological discontinuity, but not both. Really new innovations are between these two extremes.[258] Newness and radicalness can also be seen as a continuum where one end consists of minor, incremental changes and the other end of major, radical discontinuity[259]. Even though the classification between incremental and radical has been criticized for its oversimplification[260], this classification is adopted in this study with emphasis on market- and technology-related newness.

There are different types of innovations. Innovation, radical or incremental, may relate to e.g. a physical product, service, production process, organizational activity, management approach, marketing activity, or the supply chain[261]. Tushman and Andersson have shown in their study that technology typically evolves incrementally, which is boosted by discontinuous innovations happening every now and then, and

[257] Wheelwright and Clark 1992
[258] Garcia and Calantone 2002
[259] Green et al. 1995
[260] See e.g. Henderson and Clark 1990 and their discussion of architectural and modular innovations, and Shenhar 2001 and his discussion of different technology uncertainty levels.
[261] Trott 2002, Johannessen 2001

radically shaping the industry[262]. In addition, radical product innovations are typically followed by radical innovations in production processes, which are further followed by incremental improvements[263]. Thus radical and incremental changes, as well as innovation related to products, services or processes, are all highly interrelated in a cyclical manner.

Innovations are developed through an innovation process. The *innovation process* refers to the set of organizational activities that aim at resulting in the innovation. It consists of three different phases: front end, development project and commercialization[264]. As defined earlier, front end refers to the activities that take place before the launch of the formal development project phase[265]. Ideation and the processing of new product concepts normally occur in this front end phase, far before the actual development project is started. The ideation process should ensure that an adequate amount of new product ideas is produced. In addition, there should also be efficient procedures for processing these new ideas further into new product concepts, as well as mechanisms to select the most potential concepts for development projects. The front end phase is followed by the development project phase, which is typically more structured, goal-oriented, and linear compared to the earlier phase. The project phase focuses on developing selected, new product concepts into final products as effectively and efficiently as possible. Speed and timing issues are of great importance. The final phase of the innovation process is the commercialization phase, which brings new products onto the markets, thus enabling organizations to benefit from the previous development activities. It is important that these different phases function and interact seamlessly to ensure an uninterrupted 'pipeline' from new inventions to commercialized products.

The importance of innovations as a source of economic growth was already intensively discussed during the first part of the last century[266]. Organizational capability of producing innovations depends on how innovation activities have been organized and how effective the process applied is, especially in the front end of

[262] Tushman and Anderson 1986
[263] Albernathy and Utterback 1978
[264] See e.g. Buckler 1997, Zien and Buckler 1997, Koen et al. 2001
[265] Nobelius and Trygg 2002, Koen et al. 2001
[266] Schumpeter 1934

innovation. The front end needs to produce a continuous flow of new product opportunities, i.e. incremental and more radically-oriented new product concepts, in order to attract existing and new customers. The development of new, innovative products faster and more efficiently is obviously one of the top drivers of competitive advantage in industrial companies[267].

2.3.1 Organizing for the front end

The term "fuzzy front end" was first introduced in 1985[268] and it captured wider attention in the early 1990s. The definition emphasized the uncertain and chaotic nature of the early part of the innovation process. Zhang and Doll state that this uncertainty or "fuzziness" in the front end emerges from unclear customer requirements, unproven and changing technologies, and an unpredictable, business environment[269]. Buckler characterizes the front end as experimental, requiring high tolerance for uncertainty, ambiguity and chaotic phenomena, and willingness to consider the unreasonable. He further stresses that the front end phase requires a different management culture and approach compared to the other phases of the innovation process, i.e. the development project or the commercialization phase[270]. Koen et al. argue that because of the different nature of these phases, many of the management practices and activities applicable for the development project phase are inappropriate for the front end phase[271]. In order to cope with this uncertainty and fuzziness, many companies have developed a model or a systematic approach to effectively manage the front end of innovation. Table 4 illustrates the key features of front end process models found in the literature.

[267] See e.g. Cooper 1998, Clark and Fujimoto 1991, Shenhar et al. 2001
[268] Reinertsen 1985
[269] Zhang and Doll 2001
[270] Buckler 1997
[271] Koen et al. 2001

Table 4. Front end process models in the literature.

Front-end process model	Key features	Authors
Stage-Gate model	Three phases (ideation, preliminary investigation and detailed investigation i.e. business case building) and three decision gates (initial screen (qualitative), second screen (quantitative), decision on business case). Characterized by strict decision gates.	Cooper 1998
New concept development model	Five front-end elements (opportunity identification, opportunity analysis, idea genesis, idea selection, and concept and technology development), the engine (fueled by leadership and innovation culture), and external influencing factors. The model consists of elements instead of processes emphasizing the iterative and non-linear nature of front-end activities.	Koen et al. 2001, Koen et al. 2002
Funnel model	Series of funnels consisting of three front-end phases: identifying, understanding, and conceptualizing the opportunity. Divergent and convergent parts are emphasized in each phase.	Cagan and Vogel 2002
Holistic approach	Strategic-level foundation elements and project-specific elements (preliminary opportunity identification (pre-phase zero), product concept creation (phase zero) and feasibility and project planning (phase 1)).Distinction between strategic-level foundation elements and project-specific elements is emphasized. Specific sequence and duration of these activities must be tailored in each case.	Khurana and Rosenthal 1997, Khurana and Rosenthal 1998
Tailored model	Six elements after the opportunity has been identified: mission statement, concept generation, concept screening, concept definition, business analysis, and project planning. Specific sequence and duration of these activities are case-specific.	Nobelius and Trygg 2002

The Stage-Gate model for the front end phase includes three phases and three decision gates[272]. The process starts with ideation, including the generation and initial conceptualization of new ideas. At the first decision gate the ideas are screened against a set of qualitative criteria to assess the suitability of the idea. The preliminary investigation stage involves acquiring a limited amount of information regarding the idea with the purpose of discarding a large number of ideas for the next gate. If the idea passes the set of criteria at the second decision gate it is investigated in more detail. This includes e.g. the investigation of the user's needs, the competitive situation, markets, technical feasibility, financial issues, and testing of the product concept. The purpose is to build a solid business case including product definition, project justification, and an action plan through the launch. This phase is followed by gate three, which makes the decision to start a full development project, kill the

[272] Cooper 1998

initiative, or put the project 'on hold'.[273] The Stage-Gate model is one of the most linear and formal process models presented to manage the front end phase. It gives a systematic way to manage the front end and also a foundation for management to conduct formal process control activities.

The new concept development model consists of five front end elements (opportunity identification, opportunity analysis, idea genesis, idea selection, and concept and technology development) instead of processes[274]. This form illustrates that ideas are flowing in an iterative manner between different elements, possibly using a single element more than once. According to Koen et al., this differs considerably from the sequential NPD project processes in which *"looping back and redirect or redo activities are associated with significant delays, added costs and poorly managed projects"*[275]. This model tries to imitate the actual front end practices, i.e. the iterative and non-linear nature of the front end. In addition, the model emphasizes the activities before any ideas emerge. New opportunity recognition and analysis are seen as important front end activities. Management's role in setting direction and challenging goals for opportunity identification activities is stressed.

Between the two above-described extreme models (in terms of linearity and iterativeness), there are several other process models for managing the front end of innovation. The front end can be organized as a series of funnels consisting of three front end phases: identifying, understanding, and conceptualizing the opportunity[276]. The basic principle of the model is that the identified opportunities are expanded through gathering the necessary information and then filtered down to a few ideas or concepts based on the analysis and interpretation of key facts.[277] Divergent and convergent parts are found from each phase. Management has a role in decision points to evaluate outputs and select which opportunities are pursued and which are not.

A holistic approach to the front end phase emphasizes the difference between strategic-level foundation elements and project-specific elements[278]. These levels

[273] Cooper 1998
[274] Koen et al. 2001
[275] Koen et al. 2001 p. 49
[276] Cagan and Vogel 2002
[277] Ibid.
[278] Khurana and Rosenthal 1997, Khurana and Rosenthal 1998

require different management skills and levels of influence. The foundation elements, including a clear product strategy, a well-planned product portfolio and organizational structure, typically require enterprise-wide support and senior management involvement, and form the foundation for project-specific elements. Project-specific front end activities help to clarify the product concept, define product and market requirements, and develop plans, schedules and estimates of resource requirements.[279] The importance of strategic-level activities in setting a foundation for project-level activities to succeed is emphasized. Management has a critical role in creating the right set-up for operative-level activities and integrating as well as controlling decision-making at these levels effectively.

Nobelius and Trygg have analyzed three front end projects and present a front end model that includes the following elements after the opportunity has been identified: mission statement, concept generation, concept screening, concept definition, business analysis, and project planning. They argue that the specific sequence and duration of these activities depend on the type of project, and thus the actual front end route should reflect the characteristics of the specific case.[280] Tailoring an appropriate model for each case sets challenges for management to use process control in steering front end activities.

Current models for managing the front end of innovation have been criticized for adopting one single model for the front end without considering any contextual differences. Nobelius and Trygg argue that there should be alternative processes or routes and managerial freedom in the front end phase for different types of projects[281]. Reinertsen applies a quantitative approach to studying the front end phase[282], considering it as a process that can and must be optimized. He states that when the underlying economics of the situation in hand differ, the front end process should also differ. According to Reinertsen, the number, layout and sequence of filters or gates in the process are examples of issues that affect the effectiveness and efficiency of process execution. Furthermore, process flow rates, the size of process queues, flow control of the process queues, and the batch size of the process are issues that need to

[279] Ibid.
[280] Nobelius and Trygg 2002
[281] Ibid.
[282] Reinertsen 1999

be optimized in the front end context.[283] In an earlier article, Reinertsen suggested a two-track front end process depending on the time focus of the projects[284].

The above criticism against single best practice approaches indicates that the adaptation of a single process model or management approach for all kinds of initiatives in the front end may not be the optimal solution. Process models, management approaches and control mechanisms should reflect the special characteristics and needs of a specific development project. These statements are in line with the general principles of contingency theory.

2.3.2 Front end activities

Management can have an effect on the direction of development activities by influencing decisions and choices made in concrete front end activities. Front end activities are the work tasks that enable identified new opportunities to be transformed into solid product concepts. The front end models found in the literature[285] include different front end activities that are considered to be critical in effective front end execution. Based on these models and the discussion by the authors, the front end activities can be summarized to include the following eight activities: opportunity identification, idea generation, idea screening and selection, concept development, concept testing, customer need assessment, technology verification, and business analysis. These are the concrete work activities that management tries to influence by implementing control through different control mechanisms. Table 5 summarizes the key aspects of these activities with the appropriate references.

[283] Reinertsen 1999
[284] Reinertsen 1994
[285] Cooper 1998, Koen et al. 2001, Koen et al. 2002, McGrath 1996, Cagan and Vogel 2002, Khurana and Rosenthal 1997, Khurana and Rosenthal 1998, Nobelius and Trygg 2002

Table 5. Front end activities.

Front-end activity	Key aspects	References
Opportunity identification	Identification of new product opportunities driven by the company's strategies and business goals.	Cagan and Vogel 2002, Nobelius and Trygg 2002, Koen et al. 2001, Khurana and Rosenthal 1997, Gorski and Heinekamp 2002, Afuah 1998, Von Hippel 1988, Cooper 1998, Koen and Kohli 1998
Idea generation	Generating, developing and expanding alternatives for the identified opportunity. Must be separated from idea evaluation.	Koen et al. 2001, McAdam and McClelland 2002, Gorski and Heinekamp 2002, Tidd et al. 2001, de Bono 1970
Idea screening and selection	Identification and selection of the most potential ideas for further development with the help of screening criteria.	Cooper 1998, Ozer 1999, Bacon et al. 1994
Concept development	Concretizing of ideas into product concepts.	Nobelius and Trygg 2002, Koen et al. 2001, Khurana and Rosenthal 1997, Tidd et al. 2001, Ulrich and Eppinger 2003, Cagan and Vogel 2002, Bacon et al. 1994
Concept testing	Testing of concept viability internally and externally with potential customers.	Lees and Wright 2004, Ozer 1999, Tidd et al. 2001
Customer need assessment	Acquiring timely and reliable information on customer needs and user requirements.	Bacon et al. 1994, Gruner and Homburg 2000, Lukas and Ferrell 2000, Atuahene-Gima 1995, Montoya-Weiss and Calantone 1994, Salomo et al. 2003, Vicari and Troilo 1998
Technology verification	Detailed technical investigation of proposed concepts in order to assure appropriate functionality.	Cooper 1998, Koen et al. 2001, Bacon et al. 1994
Business analysis	Estimating market potential, investment requirements, competitors reactions, and overall development risks.	Nobelius and Trygg 2002, Koen et al. 2001, Koen et al. 2001, Murphy and Kumar 1996

Opportunity identification is a critical but often underestimated front end activity. Identification of a new product opportunity launches front end, project-specific development work[286]. Typically this identification is driven by the company's strategies and business goals[287]. These opportunities might emerge through a formal identification process, informal interaction in ad hoc situations, discontinuous and disruptive change situations, or just result from happy accidents[288]. Typically, companies lack systematic and effective practices that would enable them to proactively identify emerging opportunities. By knowing different opportunity recognition frameworks and methods, management can set the direction and allocate the company's resources appropriately, searching for new opportunities and creating favorable circumstances for ideas to emerge.

[286] See e.g. Cagan and Vogel 2002, Nobelius and Trygg 2002, Koen et al. 2001, Khurana and Rosenthal 1997
[287] Koen et al. 2001
[288] Gorski and Heinekamp 2002, Koen et al. 2001, Afuah 1998

Ideas must be actively generated and collected from internal and external sources. Idea generation develops and expands the identified opportunity further through a series of iterations[289]. It must be separated from idea evaluation and screening in order to enhance openness and creativity[290]. Idea generation can be stimulated by using different idea generation tools and creativity techniques[291]. Idea generation activity is especially sensitive to management's intervention and influences either in positively inspiring or negatively killing creativity. In addition, strategic frameworks, roadmaps or business models may restrict creativity during the generation of ideas. The creation of an appropriate innovation culture to support innovativeness and the development of new ideas inside the company is of importance.

The purpose of idea screening and selection activity is to identify those ideas with the most potential for further development and give immediate feedback to the inventors. Generally, this happens at the review meetings or at decision gates defined by the front end process model[292]. Several lists of different screening criteria for evaluating new product ideas have been presented in the literature[293]. The idea screening and selection activity provides management with an opportunity to influence what ideas are accepted for further development and what is an appropriate balance of a development portfolio (e.g. between incremental and radical product ideas).

The identified new opportunity is first translated into several alternative ideas or solutions and then into refined and solid concepts. Concept development represents the critical activity of the front end, as the selected idea(s) are concretized in this phase[294]. The purpose of concept development is to develop the idea in a more concrete shape and form (e.g. sketches, presentations or mockups), which helps to allocate the needed resources for further development[295]. Management can influence concept development activity by e.g. setting limitations on the developed concept or setting specific performance objectives for the product concept.

[289] Koen et al. 2001
[290] See e.g. McAdam and McClelland 2002
[291] Gorski and Heinekamp 2002
[292] Cooper 1998
[293] See e.g. Cooper 1998, Bacon et al. 1994
[294] Nobelius and Trygg 2002, Koen et al. 2001, Khurana and Rosenthal 1997
[295] Tidd et al. 2001

Concept testing is sometimes a neglected activity, since the development group may be too eager or under too much of a time constraint to launch a development project immediately once the concept is finished. However, to check the viability of new product concepts they should be tested already in the front end phase[296]. This may involve e.g. the assessment of customers' reactions to the proposed new concept, the identification of important product features and their priorities, and the assessment of the potential market size[297]. Concept testing helps to refine the concept in more detail and to avoid problems in later development phases[298]. Management has an important role in providing adequate resources for concept testing and in contributing to the involvement of different internal functions.

New product concepts must satisfy, even exceed the needs of customers. Thus, acquiring timely and reliable information on customer and user requirements is a critical activity for front end execution[299]. However, empirical evidence on the relationship between customer orientation and performance is inconclusive. While some studies argue on behalf of customer orientation[300], others take the opposite viewpoint and claim that customers are captives of functional-fixedness, having knowledge only of the ways that products are currently used[301]. Management influences customer need assessment activity by defining the overall role that customers play in the company's internal product development activities. Decisions regarding strategic alliances, customer collaboration and the overall degree of customer orientation set the limits on the tools that the development team can exploit in customer need assessment.

Technical failures are one main source of new product failures when new technologies are applied. Technology verification refers to translating customer needs into technically and economically feasible solutions, including the assessment of the functionality of potential technical solutions, technical risks, legal requirements and patent issues[302]. Management's decisions regarding the used technology and

[296] Lees and Wright 2004
[297] Ozer 1999
[298] Tidd et al. 2001
[299] See e.g. Bacon et al. 1994, Gruner and Homburg 2000
[300] Atuahene-Gima 1995, Montoya-Weiss and Calantone 1994, Salomo et al. 2003
[301] Vicari and Troilo 1998, Slater and Narver 1998
[302] Cooper 1998

technology platforms, as well as how risky an endeavor it is to pursue in the first place, influence the importance of technology verification activity in the front end.

New product concepts must be viable from a business sense to create competitive advantage for the company. Business analysis brings sound business logic to the front end activities[303]. A holistic business analysis includes the estimation of market potential, customer needs, investment requirements, competitor assessments, technology unknowns, and overall development project risks[304]. Requirements and the relative emphasis of business-related issues on management's decision criteria, e.g. in the final concept selection phase, affect how thoroughly business analyses are typically executed in the front end.

The above-described front end activities transfer identified opportunities first into embryonic ideas and finally into product concepts. Management's role is to control these activities in such a manner that the created concepts provide a good starting point for development projects. What is meant by 'good' relates to front end performance, which is discussed next.

2.4 Front end performance

Conceptual understanding of performance has a critical role in any attempt to create a normative theory. The relationship between performance and fit is a key concern in contingency theory-based research. The basic argument of contingency theory states that the fit between the organizational structure and contingency variable leads to higher performance[305]. Misfit, in turn, results in lower performance causing organizations to eventually search for alternative structural arrangements to regain that fit. Contingency theory further assumes that there is a certain level of structural variables (e.g. management control) that produces the highest performance for each level of the contingency variable (e.g. market or technology uncertainty)[306]. Thus the fit between the organizational structure and contingency variable provides an explanation for variation in organizational performance. This study is conducted on a single, front end project level, not at an organizational level. However, the principles

[303] Nobelius and Trygg 2002, Koen et al. 2001
[304] Koen et al. 2001
[305] Donaldson 2001
[306] Ibid.

of contingency theory and the concept of performance are also applicable in this kind of contemporary organizational arrangement.

Holistic theoretical or empirical studies dealing with performance in the front end of innovation are scarce. Evidently, the reason is partly the abstract nature of the front end phase where the objective measurement of performance is challenging. Much of the discussion of performance in the front end of innovation is adopted from the debate of project performance[307]. The logic behind this is that the front end phase precedes the actual development project phase, creating the premises for successful project execution. There is also a stream of literature that suggests broadening the concept of the project to include also pre-project activities such as opportunity scanning, idea generation, and preparation[308]. Proficient implementation of pre-project activities is seen as a requirement for successful project execution. Evaluation of the proficiency of preparation activities can then be done using some of the traditional project success measures. The following chapters give a basic understanding of what is meant by project success (performance) especially in the NPD context, and this is followed by a discussion of front end performance and the front end performance measures used in this study.

2.4.1 Project performance

Projects are increasingly considered as strategic means that are initiated to pursue the short- and long-term goals of the organization. Thus the debate regarding project success is partly based on and overlaps with the matter of organizational performance. In a similar way that survival is the ultimate measure for organizational performance[309], project completion (without termination) can be regarded as one type of success measure. Rational management equipped with applicable procedures and courage would terminate projects showing unwanted characteristics from the organization's point of view[310]. However, project completion as such is a poor measure of performance as it does not give adequate guidance to managers or team

[307] Herstatt et al. 2004, Kleinschmidt et al. 2005
[308] See e.g. Artto et al. 2006
[309] Dess and Robinson 1984
[310] Also termination of a project can be viewed as successful when the used resources can be reassigned to more important and profitable projects. See e.g. Kerzner 1998.

members on executing projects effectively, nor to the researchers making sound, scientific research-based conclusions.

The project management literature lacks a widely accepted definition of what constitutes project success. The frameworks developed for measuring project success are often inconsistent and individual criteria are grouped under different headings. Inconsistent measures of project success make it difficult to analyze empirical studies and interpret their findings in comparison with the existing theory. However, the theoretical discussion seems to agree that project success is a multidimensional and complex concept[311]. Comprehensive evaluation of project success should therefore reflect the different aspects of a project similarly as organizational performance is assessed from different viewpoints e.g. in the Balanced Scorecard[312]. Multidimensionality and complexity is partly caused by the fact that projects typically involve multiple stakeholders that all have their own objectives regarding the project[313]. The level of fulfillment of these needs eventually determines how these parties judge final project success. To complicate the issue more, people even inside the same stakeholder group evaluate success in different ways depending on their position in a social network with different knowledge of the overall purpose and direction of the project[314]. This makes it important to clearly state in research reports from whose perspective the success is measured and how this measurement is actually made. In the NPD context, success is sometimes measured from the project level and sometimes from the program level, thereby further increasing the complexity of the phenomenon[315].

Evaluation of project success also involves two clearly distinct but still related dimensions: project management success and success of the end result. Project management success is a short-term measure dealing with the efficiency of project execution from the managerial point of view; success of the end result deals with longer-term issues from the customer's and parent organization's point of view[316].

[311] Shenhar et al. 2001, Griffin and Page 1996, Griffin and Page 1993
[312] Kaplan and Norton 1996, Kaplan and Norton 1992
[313] Baccarini 1999, Atkinson 1999, Shenhar et al 1997, Bellasi and Tukel 1996, Freeman and Beale 1992, de Wit 1988
[314] Smith-Doerr et al. 2004
[315] Griffin and Page 1996
[316] See e.g. de Wit 1988

The end result of the project can be successful even though project management has failed. In addition there are two other issues that make the definition of project success a difficult task. First, time can have a great influence on how successfully the project is perceived[317]. A project can be defined as successful in the short run (the project is completed on schedule and within the scope limits, and the end product is acceptable), but as a failure when investigated a few years later (the end result of the project has quality problems and difficulties in maintenance), or vice versa. Second, the project type (NPD project, internal development project, customer delivery project)[318] and the project feature[319] (low-tech project vs. high-tech project) may influence the appropriateness of the success criteria used. It has been argued that project success cannot be measured objectively and unambiguously[320]. Nevertheless, however difficult it is, management should still specify what criteria will finally be used to evaluate the success of the project. This helps the project team to focus its attention on the relevant issues and to achieve a consensus on direction in the project[321].

Table 6 summarizes five different dimensions of project success: project management success, product success, stakeholder satisfaction, benefits to the organization, and preparing the organization for the future. Key aspects of these dimensions with appropriate references are illustrated in the table.

[317] Shenhar et al. 2001
[318] de Wit 1988
[319] Shenhar et al. 2001, Griffin and Page 1996
[320] de Wit 1988
[321] Baccarini 1999

Table 6. Dimensions of project success.

Dimension of project success	Key aspects	References
Project management success	A short-term measure of the level of goal achievement in terms of schedules, budgets, quality standards and technical specifications.	Atkinson 1999, Baccarini 1999, Turner 1999, Kerzner 1998, Lienz and Rea 1995, Freeman and Beale 1992, de Wit 1988, Morris and Hough 1987, Pinto and Slevin 1988, Pinto and Slevin 1983
Product success	A holistic measure evaluting the success of the end result of the project.	Atkinson 1999, Cooper 1994, Griffin and Page 1993, Freeman and Beale 1992
Stakeholder satisfaction	A measure including several, even conflicting, viewpoints on success. Each stakeholder (e.g. customer, project team, parent organization) judges project success based on the level of fulfillment of their needs.	Shenhar et al. 2001, Turner 1999, Atkinson 1999, Baccarini 1999, Kerzner 1998, Griffin and Page 1993, Freeman and Beale 1992, de Wit 1988
Benefits to the organization	A measure indicating the value (e.g. financial benefits, improvement in effectivenes and efficiency, competitive advantage) for the organization created by a project.	Shenhar et al. 2001, Turner 1999, Atkinson 1999, Griffin and Page 1996
Preparing organization for the future	A long-term measure emphasizing the ability of a project to create benefits (e.g. new market or technology opportunites, learning) that help the organization to exploit future business opportunities and to be prepared for challenges in the business environment in the future.	Shenhar et al. 2001, Cooper and Kleinschmidt 1987

Project management success consists of short-term efficiency measures that are relatively easy to gauge and are based on the 'project management' definition. Project management success measures the level of objective achievement in terms of schedules, budgets, quality standards and technical specifications that are set at the beginning of the project[322]. Project objective achievement is similar to 'the goal approach' used in measuring the performance of the organization in general, where organizations are seen as goal-seeking devices and the level of attainment of the goals (as set by senior management) determines the final organizational performance[323]. Project management efficiency cannot be used for measuring front end performance. There are no specifications, performance standards or quality targets in the front end

[322] Atkinson 1999, Baccarini 1999, Turner 1999, Kerzner 1998, Lienz and Rea 1995, Freeman and Beale 1992, de Wit 1988, Morris and Hough 1987, Pinto and Slevin 1983
[323] Ford and Schellengerg 1982, Parsons 1961

of innovation. In fact, these are the elements that are defined in a product concept, which is the output of the front end. The defined budget does not necessarily exist but the work is based on a lump sum budget which is intended for searching for new product concepts. These project management efficiency measures are actually opposite to the current theoretical understanding of successful front end execution. The prevailing understanding is that versatile exploration and iteration rounds, i.e. thorough the front end phase, actually improve overall project success even though the front end phase can take a longer time to accomplish[324].

Product success refers to the success of the end result of the project. It is a holistic and context-specific measure considering e.g. quality, maintainability, reliability, price/performance ratio, uniqueness of attributes, or the technical performance level of a product[325]. Product success is evidently an important measure of success because it is the dimension that a customer values the most. The final end product is a concrete reference point to which customers compare the fulfillment of their needs and expectations. Product success is also a relevant success measure of front end performance. Even though a final product does not exist yet, there is a product concept describing the necessary features and a rough structure that can be investigated to estimate the product's level of success.

Each stakeholder judges a project's success based on the level of fulfillment of their needs. Organizations can be conceptualized as a coalition of different constituencies with dissimilar levels of aspiration and therefore fulfillment, which influences their perceived performance of organizational action[326]. Similarly, a project can be regarded as a temporary organization involving different stakeholders with different ambitions toward that project[327]. Typically, the customer, the project team and the parent organization are considered the most important stakeholders[328]. Obviously, there are several very context-specific measures for each stakeholder. Evidently, no project can satisfy these often conflicting needs completely, but still these needs should be acknowledged and rationally analyzed. This should lead to the conscious

[324] Cooper and Kleinschmidt 1987, Thomke and Fujimoto 2000
[325] Atkinson 1999, Cooper 1994, Griffin and Page 1993, Freeman and Beale 1992
[326] Ford and Schellenberg 1982, Thompson 1967
[327] de Wit 1988
[328] Shenhar et al. 2001, de Wit 1988, Freeman and Beale 1992, Turner 1999, Kerzner 1998, Atkinson 1999, Baccarini 1999, Griffin and Page 1993

prioritization of the most important project goals. In this study, management is considered a stakeholder party that is used to judge front end performance. However, since customer satisfaction is of importance in any developed product, some measures indicating expected customer satisfaction are also used to judge front end performance.

Projects are initiated to create value for the organization (the organization which executes the project). This value refers to business benefits which can be evaluated with various criteria. Return on investment and growth in sales are ultimate measures of business success in organizations in general[329]. Similarly, the level of sales, profits and profit margins are recommended for evaluating success in the NPD context[330]. Measures such as the return on investment and internal rate of return are appropriate especially in more radical projects since they take the time value of money into account[331]. Internal development projects that are not initiated to create direct financial profits can be evaluated e.g. based on the level of improvement in effectiveness and efficiency[332]. Some of these criteria for gauging organizational benefits are difficult to use in the front end of innovation. Expected sales levels, market shares, profit margins and financial gains are hard to estimate beforehand and include a great deal of speculation as the actual introduction of the product to the market may be a few years ahead.

Preparation for the future refers to long-term success measures that take the attention beyond short-term efficiency and financial measures. Preparing an organization for the future relates to project results that help the organization to exploit future business opportunities and be prepared for emerging challenges in the business environment[333]. New opportunity windows for novel product categories or entrance into new markets, the creation of new skills, technological competences, organizational competencies or adaptation capabilities are examples of the measures used in the NPD context[334]. Evidently, this is an important performance measure also in the front end of innovation. It can further be argued that even unsuccessful and terminated front end

[329] Ansoff 1965
[330] Shenhar et al. 2001, Griffin and Page 1996
[331] Griffin and Page 1996
[332] Shenhar et al. 2001, Atkinson, 1999
[333] Shenhar et al. 2001, Cooper and Kleinschmidt 1987
[334] Ibid.

effort brings some benefits – if nothing else is accomplished, the development group at least knows that the solution for a given opportunity/problem cannot be found in that investigated, particular direction.

2.4.2 Evaluation of front end performance

Evaluation of front end performance is an even more challenging task compared to judging project success. The critical question is should there be different performance measures for the front end or are the project success measures applicable also in the front end? Since the front end of innovation is a precursor to the development project, the used performance measures can at least be partly similar to project success measures. In other words, it is possible to apply indicators that measure the contribution of the front end of innovation to the typical project success measures. Some of the project success measures (e.g. product success, preparing the organization for the future) can be applied to the front end of innovation and the created product concept can be used as a similar reference point as the final product at the end of innovation process. The partial use of similar success measures in separate innovation process phases provides a consistent way for measuring performance during the innovation lifecycle. Also the current theory seems to support using partly similar measures since those few normative studies of the front end of innovation have ended up with the same solution[335].

The objective evaluation of front end performance is challenging. The lack of exact objective performance measures such as sales or profit margin figures at this stage leads to an emphasis on subjective, perception-based performance evaluation criteria[336]. Evaluating performance through perception puts more requirements on the person evaluating overall front end performance[337]. That person needs to have a holistic and balanced understanding of different success dimensions. In addition, the legitimacy of evaluation can be increased if the person has the possibility to compare the success with other similar types of projects, i.e. a view across a portfolio of similar projects.

[335] See e.g. Kleinschmidt et al. 2005, Herstatt et al. 2004
[336] Smith-Doerr et al. 2004, Shenhar et al. 2001
[337] Smith-Doerr et al. 2004

Projects aiming at radical innovations need to be evaluated with special performance measures. The discussion in project strategy literature indicates that innovation projects differ in terms of their project strategies and should be evaluated with different success criteria[338]. Innovation projects have a different level of autonomy under the parent organization, which influences the direction of the project strategy and which further dictates the appropriate success measures. The parent organization's subordinate projects (i.e. more incremental projects) should apply measures emphasizing customer satisfaction and organizational benefits. Projects are seen more as implementation vehicles of business strategies. The parent organization's autonomous projects (i.e. more radical projects), in turn, can be appropriately evaluated in terms of the impact on business, creation of new markets or renewal of strategy[339]. Projects are seen more as vehicles challenging or altering the strategy of the parent organization. In other words, more short-term and immediate performance measures should be relied on for incremental projects, whereas long-term and more forward-looking performance measures are appropriate for radical projects. This gives theoretical justification to investigate front end performance in the light of two distinct performance measures.

A product advantage is a key issue in terms of new product success; it contributes to the adoption of a new product by the market[340] and it is found to strongly impact new product performance[341]. A product concept is the final target pursued during the front end project execution. As a key deliverable of the front end of innovation[342], the product concept includes a description of the form, function, and features of a product and it typically includes a set of specifications and the business case built based on the concept[343]. Concepts of tangible products may also include sketches or CAD models[344], or preliminary and rough versions of prototypes[345]. Even though the concept is more abstract than the product and may be modified during the project, it provides a reasonable reference point for estimating the product advantage, final

[338] Artto et al. 2008b, Artto et al. 2008
[339] Artto et al. 2008
[340] Rogers 2003
[341] Calantone et al. 2006, Veldhuizen et al. 2006, Langerak et al. 2004, Montoya-Weiss and Calantone 1994, Cooper and Kleinschmidt 1987
[342] Kim and Wilemon 2002, Nobelius and Trygg 2002, Koen et al. 2001
[343] Ulrich and Eppinger 2003
[344] Khurana and Rosenthal 1997
[345] Cagan and Vogel 2002

product success and its ability to prepare the organization for the future. Product concept superiority is a short-term immediate measure for front end performance. The front end phase is also characterized by exploration activities, trial-and-error learning, and iterative development, which result in a product concept[346]. The front end of innovation contributes to the ability to adapt to changes, to organizational learning and to strategic renewal, which enable the organization to be prepared and confront challenges in the future business environment. From a business perspective, product innovation is considered to be a vital factor for the firm's adaptation capabilities and strategic renewal as the environment changes[347]. Strategic renewal is a long-term forward-looking measure for front end performance.

Product concept superiority can be evaluated based on a product concept that is defined in the front end. Product superiority can be defined in terms of superior price/performance characteristics and unique features in relation to competing products in the market[348]. Product advantage and differentiation in the eyes of customers are also important determinants of product success, and product superiority must be realized also by the targeted customers. For example, Shenhar et al. have emphasized the importance of the impact a product has on the customer; the product's ability to solve customers' problems and the level of customer satisfaction among other things are defined as important measures of customer impact[349]. In addition, the competitive advantage created by the product has been used as an overall measure of the success of the front end outcome[350] or the end product in the NPD context[351].

Strategic renewal is enabled by new knowledge, access to new markets and the use of new technologies. The renewal of NPD projects is typically measured in terms of two dimensions, whether opportunity windows for new product categories have been created or an entrance into new markets[352]. In addition, creation of new skills, technological competences, organizational competencies and adaptation capabilities are used to evaluate the impact of the project on the long-term success of the

[346] Koen et al. 2001
[347] Danneels 2002, Eisenhardt and Tabitizi 1995
[348] Cooper 1994
[349] Shenhar et al. 2001
[350] Kleinschmidt et al. 2005
[351] Herstatt et al. 2004, Griffin and Page 1996
[352] E.g. Cooper and Kleinschmidt 1987

organization[353]. Shenhar et al. emphasize that "learning measures" are important especially in evaluating the success of high-tech projects that may be initiated for reasons beyond immediate profits, for learning purposes[354]. The strategic renewal performance measure focuses on the ability of the front end of innovation to create an opportunity window for new market entries or NPD activities[355]. In addition, the know-how created in terms of target markets and utulized technologies are used as a reference point to evaluate the level of strategic renewal[356]. Later studies have confirmed that creating windows for new opportunities is further associated with financial performance[357].

Based on the above, *front end performance* is defined as the perceived superiority of product concepts or/and the contribution to strategic renewal. The influence of different front end activities on strategic renewal[358] and new product success in general[359] have been investigated in the literature but the role of management control on strategic renewal and product concept superiority is still unexplored in the front end of innovation. This study aims at filling this theoretical gap.

Front end performance is evaluated in this study in terms of product concept superiority (product success) and strategic renewal (preparing the organization for the future). These two performance constructs can be reasonably evaluated just after front end execution based on the understanding generated during the front end. The strategic renewal success measure is an intermediate construct measuring the possibility of the front end project contributing to strategic renewal.

These constructs are evaluated based on the perception of a director-level person who has been responsible for controlling a particular front end project in question. Senior managers are considered to have a more knowledgeable, balanced and multiple perspective on front end performance compared to e.g. project managers, due to their

[353] Shenhar et al. 2001
[354] Ibid
[355] Based on ideas of Cooper and Kleinschmidt 1987, Kleinschmidt et al. 2005
[356] Herstatt et al. 2004, Kleinschmidt et al. 2005
[357] Kleinschmidt et al. 2007
[358] Kleinschmidt et al. 2005
[359] E.g. Murphy and Kumar 1996, Koen et al. 2001

central role in social networks (formal and informal) in the organization[360]. In this study front end performance is evaluated from the parent organization's (the organization who executed the front end project) perspective, and other stakeholders are ignored in success evaluation. Customer perspective is considered, however, because a satisfied customer can be regarded as being one dimension of product success. Only satisfied customers make repeat purchases and build company reputation and brand image in target markets. Finally, the evaluation of front end performance is done on a single front end project level, not at a company level. This reflects the general need of practitioners to better understand NPD success and factors contributing to success in a single project level[361].

2.5 Market and technology uncertainty

Market uncertainty and technology uncertainty are investigated as contingency factors in this thesis based on the general line of research which considers technology and the market as the main uncertainties in the NPD context[362]. Since the foundation for studying contingency factors lies in contingency theory and in the concept of task uncertainty, these are discussed first, followed by a more thorough discussion of market and technology uncertainties.

Task uncertainty has a significant influence on the optimal way of organizing work tasks. This argument is supported in contingency theory[363], especially in organic theory[364], and the discussion of mechanistic and organic structures that are at the core of structural contingency theory[365]. Contingency theory is based on three premises: first, that there is an association between contingency (e.g. market or technology uncertainty) and the organizational structure (e.g. management control), second, that contingency determines the organizational structure and third, that there is a fit between some level of the organizational structure and each level of contingency,

[360] Smith-Doerr et al. 2004
[361] Griffin and Page 1993
[362] Garcia and Calantone 2002, Tidd et al. 2001, Lynn and Akgun 1998, Danneels and Kleinschmidt 2001, Yap and Souder 1994
[363] See e.g. influential works of Burns and Stalker 1961, Thompson 1967, Lawrence and Lorsch 1967, Perrow 1967, Galbraith 1973, and Chandler 1972
[364] Donaldson 2001
[365] Burns and Stalker 1961

which leads to higher performance[366]. Contingency theory offers a foundation on which to investigate the potential moderating role of market and technology uncertainty on the relationship between management control mechanisms and front end performance.

There are several conceptions of what uncertainty is and what it consists of. For example, uncertainty has been discussed e.g. in terms of a property of the business environment[367], lack of clarity of information[368], a difference between the required and possessed amount of information[369], perceived (subjective) environmental uncertainty[370], risks and risk management[371], task variability and task analyzability[372], the difference between uncertainty and equivocality[373] and complexity[374]. In this thesis, I have adopted the following definition of uncertainty by Galbraith: "*the difference between the amount of information required to perform the task and the amount of information already possessed by the organization"*[375]. Based on the information processing theory, Galbraith has argued that the best way to accomplish a certain task, i.e. to organize its execution, is dependent on the uncertainty and diversity of the performed task. Diversity in resources, outputs and level of performance increases factors and interconnections between these factors that are both necessary to take into account in decision-making.[376]

Perrow's notable work distinguished task uncertainty in terms of task variability and task analyzability. Task variability relates to the number of exceptions confronted during task execution, i.e. "the degree to which stimuli are perceived as familiar or unfamiliar"[377]. Task analyzability, in turn, refers to the degree to which known procedures exist for task execution.[378] Perrow has argued that routine technologies (including analyzable tasks with few exceptions) are best dealt with formal and

[366] Donaldson 2001
[367] Hatch 1997
[368] Lawrence and Lorsch 1967
[369] Galbraith 1973
[370] Duncan 1972, Milliken 1987
[371] Ward and Chapman 2003
[372] Perrow 1967
[373] Daft and Lengel 1986, Conrath 1967
[374] Thompson 1967, Tidd et al. 2001
[375] Galbraith 1973 p. 5
[376] Galbraith 1973
[377] Perrow 1967 p. 196
[378] Ibid.

centralized structures. Non-routine technologies (including unanalyzable tasks with many exceptions) require flexible and polycentralized (organic) structures. Later studies applying Perrow's model proved that work groups with a different amount of task uncertainty (measured in terms of task variability and task analyzability) were structured differently[379]. Task analyzability and task variability have been related to the newness of a project in terms of technology and the market. New target market entries or new applied technologies imply that experienced task analyzability is lower and task variability is higher compared to those cases where markets and technologies are familiar to the company.[380] This line of argumentation regarding the connection between task uncertainty and technological or market novelty is generally supported in the innovation management literature[381].

Several uncertainty matrices have been built in the innovation management context by different authors[382] and most of them have market and technology uncertainty as defining parameters[383]. High market uncertainty means that stepping into new markets causes a lack of information about customers' needs and market characteristics. Other sources of market uncertainty include e.g. competitors' responses, technology adoption, and own development activities; the level of product demand and the length of the product lifecycle; and unclear customer preferences of product characteristics[384]. High technology uncertainty refers to the extent to which product structure and functionalities are understood. The technology uncertainty may emerge from e.g. the choice of technology, the combination of product features, raw materials and components, suppliers' technological capability, manufacturability, and regulatory or standardization issues[385]. Technology and market uncertainties are interlinked with organizational uncertainties about knowledge, capability and resource availability to execute the task.

[379] Van de Ven and Delbecq 1974
[380] Moenaert et al 1995
[381] See e.g. Herstatt et al. 2004, Tatikonda and Rosenthal 2000, Lynn and Akgun 1998, Chen et. al. 2005
[382] Garcia and Calantone 2002, Lynn and Akgun 1998, Kleinschmidt and Cooper 1991
[383] See e.g. Lynn and Akgun 1998, Kleinschmidt and Cooper 1991
[384] Chen et al. 2005, Zhang and Doll 2001, Lynn and Akgun 1998, Moenaert et al. 1995
[385] Ibid.

The level of uncertainty has been used to distinguish radical innovations from incremental development. When both market and technology uncertainty is high the innovation is typically called radical, and in the opposite case incremental[386]. From the information processing perspective, the distinction between incremental and radical innovation is notable. In the case of incremental innovation, the company can rely on in-house information and knowledge as well as on experiences from earlier development interventions. A company dealing with radical innovations faces a much more challenging task in translating new customer needs into new technical features. There is not as much existing information or knowledge available in-house. The company needs to involve itself in heavy external information gathering, processing and analyzing procedures as well as internal competence development activities. Radically-oriented innovations may require learning-based innovation strategies (trial-and-error) since exact course setting and target definition may be difficult[387].

Besides the market and technology familiarity, how the market and technology fit into an organization's existing competencies and capabilities is an important determinant of task uncertainty. A product targeted at new markets and applying new technologies is 'not so new' if there are synergies between the organization's internal, existing resources. Danneels and Kleinschmidt have found that it is the mere market and technology fit of a new product with a firm's existing competencies than market or technology familiarity itself that has an association with project performance.[388]

Successful NPD project teams are characterized by maximum uncertainty reduction during the front end phase of the innovation process. The more the innovation team reduces the uncertainty, i.e. closes the gap between required and possessed information about user needs, technology, competition, and the required resources, the higher the possibility is to make a commercially successful product[389]. Successful uncertainty reduction in the front end phase decreases the need for change in later phases of the innovation process, thus resulting in higher product development success. From the information processing perspective, all the front end activities can be considered as uncertainty reduction activities where embryonic ideas are developed

[386] Herstatt et al. 2004, Lynn and Akgun 1998, Balachandra and Friar 1997
[387] Lynn and Akgun 1998
[388] Danneels and Kleinschmidt 2001
[389] Moenaert et al. 1995

into tangible product concepts. Similarly, management control mechanisms such as a stage-gate model and its decision gates can be considered as mainly being devices controlling uncertainty reduction[390] where the output of the previous phase is accepted to be an adequate starting point for subsequent development phases.

All the available and relevant information cannot naturally be processed by the organization. Managers find information sources, create decision rules, and make structural arrangements in order to achieve an adequate understanding of the uncertain event[391]. It is management's responsibility to get uncertainty reduced so that their organization may operate in an efficient manner[392]. Different management control mechanisms are created and used to steer the front end activities contributing to uncertainty reduction.

Existing theory on NPD seems to strongly agree that task uncertainty is a critical contingency which influences the optimal organizational structure and management processes in the NPD context[393] and that task uncertainty can be measured in terms of the newness of applied technologies and targeted markets[394]. The more new technology the product includes or the more unfamiliar the target market is, the more uncertainty the development task includes and the more intensive information gathering and processing is required. Management control studies in general indicate that task uncertainty influences the applicability of management control mechanisms[395] and empirical studies show that applied management control mechanisms change depending on uncertainty[396]. However, there is a lack of research on studying the influence of market or technology uncertainty on the applicability of management control mechanisms in the front end of innovation characterizing extreme conditions in terms of uncertainty.

[390] See e.g. Souder and Moenaert 1992
[391] Daft and Lengel 1986
[392] Thompson 1967
[393] Tidd et al. 2001, Lynn and Akgun 1998
[394] Garcia and Calantone 2002, Tidd et al. 2001, Danneels and Kleinschmidt 2001, Lynn and Akgun 1998, Yap and Souder 1994
[395] Ouchi 1979, Ouchi and Maguire 1975
[396] Kirsch 2004, Choudhury and Sabherwal, 2003

In this thesis, *market and technology uncertainty* is measured in terms of the level of market or technological newness respectively in the development task. The influence of market and technology uncertainty on the applicability of different management control mechanisms is investigated through moderated regression analyses.

2.6 Synthesis of literature review

Management can direct front end activities by taking an active controlling role in the very early phase of the innovation process. Implementing control in the front end is not, however, a trivial task. Front end activities requiring a high amount of creativity are extremely prone to management's influence. The wrong type and amount of control can kill innovativeness, which is the vital precondition for successful front end execution. Based on the literature analysis, seven different management control mechanisms (input control, front end process formalization, outcome-based rewarding, strategic vision, informal communication, participative planning, and intrinsic task motivation) were selected and investigated in this study (Figure 1). These are typical management control mechanisms used in the NPD context. In addition, these mechanisms represent different dimensions of Hales's framework (focus of control, formality of control, interactivity of control, and locus of authority to implement control), thus giving a broad illustration of their applicability[397].

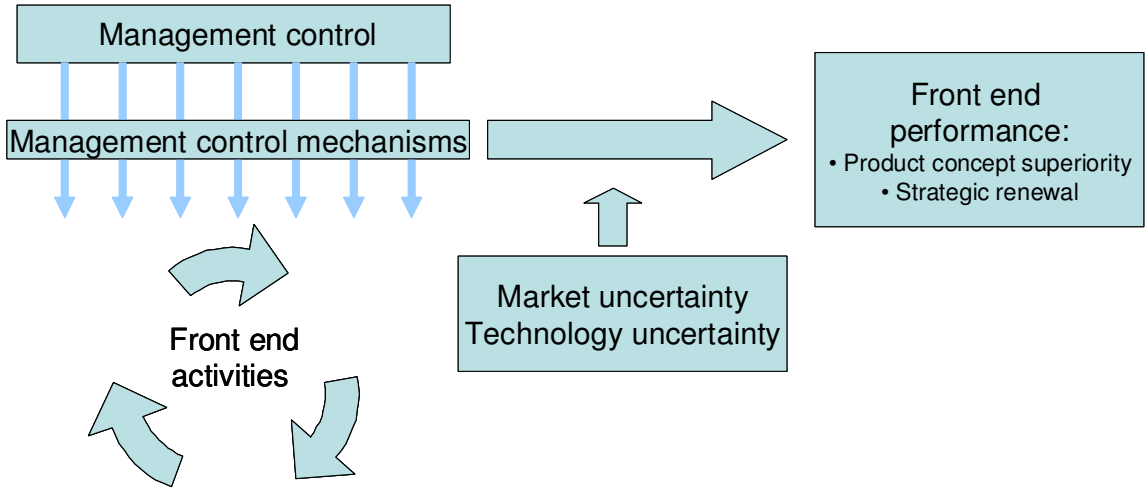

Figure 1. Theoretical framework of dissertation.

[397] Hales 1993

Management control focuses on directing the concrete front end activities (Figure 1). These activities include the eight critical work activities (opportunity identification, idea generation, idea screening and selection, concept development, concept testing, customer need assessment, technology verification, and business analysis) illustrated earlier. These activities translate identified new product opportunities first into embryonic ideas and then into final product concepts. A cross-functional group including a group leader and group members is the main actor taking care of these activities in the front end.

The front end activities aim at best possible performance. Front end performance in this study is measured in terms of product concept superiority and strategic renewal reflecting both short-term and long-term aspects of performance (Figure 1).

Typically, organizations choose an appropriate set of different control mechanisms that provide adequate control over front end activities in a cost-efficient way. According to contingency theory, the appropriateness of the used control mechanisms is defined by the uncertainty of the development project. The influence of market and technology uncertainty on the appropriateness of using front end process formalization and outcome-based rewarding as control mechanisms is investigated here (Figure 1).

3 HYPOTHESES DEVELOPMENT

***"You've got to think about big things while you're doing small things, so that all the small things go in the right direction."* – Alvin Toffler**

Seven theoretical control constructs have been selected in this study to investigate management control in the front end of innovation. These are input control, front end process formalization, outcome-based rewarding, strategic vision, informal communication, participative planning, and intrinsic task motivation. These control mechanisms are typical control mechanisms used by practitioners in companies and thus reflect the empirical reality. They also represent different types of control mechanisms thus giving a broad perspective on management control. The association of these control mechanisms with front end performance, namely product concept superiority and strategic renewal, are defined in the hypotheses made. In addition, the influence of market and technology uncertainty on the applicability of front end process formalization and outcome-based rewarding is hypothesized. The hypotheses for these constructs are put forward in the following chapters and are further tested through regression analysis.

3.1 Input control

Management has many opportunities to control the inputs into front end work, especially by defining the front end task and allocating resources for the development intervention. Importance of task definition is widely discussed and recommended in the NPD context[398] but seldom empirically tested in terms of its influence on performance. Management may set up or approve a written task definition[399], contract[400] or mission statement[401] that defines the expected product, business and performance objectives, target markets, and stakeholders[402], and possible limitations[403] for concepts and rough time, resource and cost targets. The task definition brings more focus to the development work and increases commitment

[398] Wheelwright and Clark 1992, Smith and Reinertsen 1998, Schilling and Hill 1998, Ulrich and Eppinger 2003
[399] Wheelwright and Clark 1992, Smith and Reinertsen 1998
[400] Schilling and Hill 1998, Davila 2000
[401] Ulrich and Eppinger 2003
[402] Ulrich and Eppinger 2003, Schilling and Hill 1998
[403] Rockness and Shields 1984, Rockness and Shields 1988, Sundbo 1996, Ulrich and Eppinger 2003

especially if the team is involved in negotiating the task, thus increasing the likelihood of success. The defined contract book also provides a basic tool for monitoring and evaluating the work of the development team during the front end. Davila illustrated in his case studies that the main purpose of this kind of written contract was, instead of increasing the commitment or the focus of the task, to also bring a consensus of expected divergent objectives regarding the development task[404].

The essence of input control is assuring that the "right things" are pursued as an intermediary deliverable for the development project phase. Specification of strategic performance goals gives purpose and direction for the team's conceptualization work[405], promotes cross-functional co-operation[406], gives focus by setting constraints[407], and helps to increase the consensus by removing competing interpretations of expected outcomes[408]. McDonough has investigated factors contributing to the success of cross-functional teams in a product innovation context and concludes that establishing clear and stable goals contributes the most to success[409]. The direction should be vague enough to provide room for discretion, creative problem solving and local autonomy. Furthermore, strategic goals may encourage R&D employees to pursue and achieve even very challenging results[410]. That is, development group members are willing to stretch their capabilities in order to attain targets. The well-established goal-setting theory argues on behalf of setting specific and challenging goals, particularly in routine types of work activities, that are further associated with higher performance[411]. In complex and non-routine tasks goal-setting is more challenging due to difficulties in measuring performance objectively and accurately[412].

[404] Davila 2000
[405] Cooper 1998, Imai et al. 1985, Wheelwright and Clark 1992, McDonough 2000, Bonner et al. 2002, Zhang and Doll 2001
[406] Pinto et al. 1993
[407] McDonough 2000
[408] Zhang And Doll 2001
[409] McDonough 2000
[410] Sundbo 1996, Imai et al. 1985
[411] Locke 1968, Locke and Latham 1990, Campbell and Furrer 1995
[412] Latham and Yukl 1975

Allocating particular human resources to the front end task greatly affects innovation outcomes. Both the choice of the team leader[413] and team members[414] are important to the product's success and the development of new business. High expectations are directed at the team leaders who should lobby for resources, share the team's vision, make operative decisions, lead the team, and also have the authority to influence the surrounding organization[415]. Team leaders translate top managers' expectations into operational decisions and minimize disruptions caused by external disturbances and contradictory demands[416]. Clark and Fujimoto emphasize that such highly skilled "heavyweight" managers that have direct access to the required resources and full responsibility of task execution are needed especially when the project deals with uncertain, diverse and latent market needs[417]. Smith and Reinertsen emphasize three important factors contributing to success in team leader allocation: asking for a volunteer team leader (from potential candidates), using a leader in a management role (not a technical role), and giving the leader adequate power[418].

The front end team needs to have a sufficient knowledge base, suitable personal characteristics, and capabilities to do the job successfully[419]. Besides sufficient knowledge, the team composition should be considered in terms of cross-functional expertise, attitudes and motivation to achieve success[420]. Functional diversity inside the team increases the amount and variety of available information which further makes the development process quicker and improves performance[421]. Diversity of opinions and viewpoints has been considered particularly relevant when radical new concepts are sought[422]. of staffing quality in terms of too small groups or inexperienced team members[423] or wrong sets of competencies[424] can form obstacles to high project performance. Quantity, beside quality, in terms of adequate resources

[413] Stevens and Burley 2003, McGrath 1996, Nonaka 1988, Smith and Reinertsen 1998, Brown and Eisenhardt 1995
[414] E.g. Brown and Eisenhardt 1995, Kim and Wilemon 2002, McDonough 2000
[415] Brown and Eisenhardt 1995, Wheelwright and Clark 1992
[416] Nonaka 1988
[417] Clark and Fujimoto 1991
[418] Smith and Reinertsen 1998
[419] Snell 1992, Merchant 1985, Anthony 1988
[420] Brown and Eisenhardt 1995, Clark and Fujimoto 1991, Nonaka 1988, Imai et al. 1985, Dougherty 1992, McDonough 2000
[421] Brown and Eisenhardt 1995, McDonough 2000
[422] Cagan and Vogel 2002, McDermott and O'Connor 2002
[423] Gupta and Wilemon 1990
[424] Thamhain and Wilemon 1987

loaded in the front end to find and solve design problems early in the process has been linked to superior development performance[425]. As task definition, goal specification and resource allocation, i.e. input control mechanisms, have all been identified as central components of innovation success in earlier studies, the first hypotheses are stated as follows:

H1a: Input control is positively associated with product concept superiority.
H1b: Input control is positively associated with strategic renewal.

3.2 Front end process formalization

Management can try to ensure that activities considered necessary and critical for the success of new product innovations are thoroughly accomplished for example by setting up formal processes, reviewing results periodically, monitoring work activities and progress, and establishing reporting procedures. Process formalization in this study means specifying the procedures to be followed and monitoring that work activities are proceeding in accordance with the defined procedures.

Process control is typically used in routine, structured and independent work tasks when appropriate work processes leading to the desired end results are known[426]. Classical contingency theory makes the distinction between mechanistic and organic structures[427] stating that an increase in task uncertainty causes a reduction in formalization and an increase in decentralization[428], leading toward more organic organization structures. The front end phase, being an experimental and even chaotic endeavor, is not so fertile ground for process control or process formalization based on the above arguments.

Process models have been developed to decrease fuzziness and increase a systematic approach in the front end of innovation[429]. The novel development problems call for information transfer between organizational functions, which further increases interdependence between functions and the need for integrating work activities.

[425] Thomke and Fujimoto 2000
[426] Ouchi 1977, Ouchi 1979, Eisenhardt 1985
[427] Burns and Stalker 1961, Donaldson 2001
[428] Donaldson 2001
[429] See e.g. Cagan and Vogel 2002, Nobelius and Trygg 2002, Koen et al. 2001, Cooper 1998, Khurana and Rosenthal 1998, McGrath 1996. See Chapter 2.3.1 for the introduction of different process models.

Formalization removes the need for excess communication and brings structure in the middle of uncertainty and chaos. Ulrich and Eppinger state that the front end phase, compared to other development phases, is the phase where the coordination of different expertise is the most essential[430]. Khurana and Rosenthal emphasize that a formal approach means implementing an explicit and widely known process with clear decision-making responsibilities and specific performance measures[431]. The decision-making structure in the form of decision gates or review points is typically defined together with the front end process model. Tatikonda and Rosenthal have pointed out that periodic reviews are important especially for senior management providing a time and place for intervention and for giving guidance regarding project decisions[432]. The existence of specific review points also decreases the probability that senior management gets too involved, i.e. too deeply, in operative decision-making. The right timing and existence of adequate information to make decisions in these review points is critical[433]. A variety of benefits have been associated with process formalization, e.g. the ability to focus, the possibility for managers to intervene and give guidance on project decisions, the possibility for replication and learning, and improved coordination and integration[434]. Tatikonda and Rosenthal found in their survey study that a greater degree of formality in development projects in general led to project execution success[435]. Some other studies suggest that new product success may, at least partly, depend on the existence and efficiency of a defined, formal process model also in the front end of innovation[436].

On the other hand, formal process models have been criticized because they promote using one single model for the front end without considering any contextual requirements, e.g. differences between incremental and radical innovations[437]. Some process models, indeed, favor a more iterative and informal approach that draws attention to the main tasks in the front end or prevailing innovation culture rather than

[430] Ulrich and Eppinger 2003
[431] Khurana and Rosenthal 1998
[432] Tatikonda and Rosenthal 2000
[433] McGrath 1996
[434] Tatikonda and Rosenthal 2000, McGrath 1996, Bonner et al. 2002, Ulrich and Eppinger 2003, Hertenstein and Platt 2000, Thomke and Fujimoto 2000
[435] Tatikonda and Rosenthal 2000
[436] Koen et al. 2001, Montoya-Weiss and O'Driscoll 2000, Khurana and Rosenthal 1998
[437] Nobelius and Trygg 2002, Buggie 2002

their linear order or decision-making points[438]. Several disadvantages have been connected with process formalization, e.g. decreased innovativeness, increased corner-cutting activities, negative attitudes among employees, excess bureaucracy, and decreased flexibility[439]. In addition, strict formal procedures may hinder adaptation to changing circumstances and emerging new information[440]. Kirsch has shown in her case studies that unstructured and novel characteristics of the requirements determination phase of an information system project did not enable the use of existing formal mechanisms, but forced the use of more informal mechanisms[441]. Amabile emphasizes that granting a choice over applied work processes fosters creativity by increasing employees' sense of ownership and intrinsic motivation and allows employees to maximally utilize their substance expertise and creative-thinking skills[442]. Ramaswami warns that excessive process formalization may actually lead to dysfunctional behavior among employees[443].

Formal process control has also been negatively associated with project performance[444], e.g. in terms of delays, cost overruns, lower product performance, and lower team performance in projects. Abernethy and Brownell found that process formalization led to negative results especially in projects with high uncertainty[445]. Again, prior research has typically investigated development projects as a whole without considering the differences between project phases. As prior research tends mostly to associate the use of process formalization with negative consequences in uncertain conditions, and because the front end of innovation is characterized by high uncertainty (e.g. compared to the development project phase), the following hypotheses for front end process formalization are stated:

H2a: Front end process formalization is negatively associated with product concept superiority.
H2b: Front end process formalization is negatively associated with strategic renewal.

[438] Koen et al. 2001, Khurana and Rosenthal 1998
[439] Bonner et al. 2002, Tatikonda and Rosenthal 2000, Hertenstein and Platt 2000, Amabile 1998, McGrath 1996
[440] Bonner et al. 2002, Tatikonda and Rosenthal 2000
[441] Kirsch 2004
[442] Amabile 1998
[443] Ramaswami 1996
[444] Bonner et al. 2002, Abernethy and Brownell 1997
[445] Abernethy and Brownell 1997

3.3 Outcome-based rewarding

Outcome-based rewarding means integration of personal and group incentives with the achievement of defined goals. Managers set performance standards, evaluate results and reward the front end group respectively. Rewarding and other output control mechanisms are generally considered powerful when the precise measurement of expected outcome is possible, and when other alternative control modes such as process control are not possible[446].

Research on the use of outcome-based rewards shows conflicting evidence on the applicability of output control[447]. Rewards are typically seen as a key driver nourishing employee initiation capability which, in turn, may contribute to performance. Rewarding can positively influence e.g. intrinsic motivation (especially non-monetary rewarding), knowledge sharing, and performance, especially when measured in terms of quantity[448]. These statements are in line with expectancy theory, which argues that employees are motivated to pursue greater performance when the clear linkage exists between their effort and rewards[449]. Rewarding in its versatile forms (monetary, recognition, promotion etc.) is a powerful control mechanism as it can greatly influence the whole organizational culture when used systematically and consistently[450].

Output control brings efficiency if the expected outcome can be precisely defined. However, output control is sometimes used in situations where it is not appropriate, for example in task activities including high uncertainty and complexity[451]. Rewarding has also been associated with dysfunctional behavior, decreased intrinsic motivation, hampered creativity, and reduced risk-taking behavior[452]. Jenkins et al. concluded in their meta study that rewarding has no influence on performance measured in terms of quality of output[453]. Particularly in the context of NPD, output-

[446] Ouchi 1979, Ouchi 1977
[447] See Jenkins Jr. et al. 1998 for a meta-analysis of the topic.
[448] Simons 1995, Bartol and Srisastava 2002, Jenkins Jr. et al. 1998, Sarin and Mahajan 2001, Amabile et al. 1996
[449] Baron and Byrne 1997
[450] O'Reilly 1989
[451] Ouchi and Maguire 1975
[452] Simons 1995, Ramaswami 1996, Bartol and Srisastava 2002, Jenkins Jr. et al. 1998, Amabile et al. 1996, Snell 1992
[453] Jenkins Jr. et al. 1998

based rewarding has been troublesome and some recent studies have showed negative or non-existing relationships between outcome-based rewarding and NPD performance[454]. Sarin and Mahajan found that while the rewarding of NPD teams based on results may work in incremental projects, there are counterproductive effects on product quality in risky projects[455]. Bonner et al. did not find any correlation between the outcome-based team reward system and project performance[456].

Although a reward system has been considered as relevant in reinforcing the right values and behaviors among employees[457], employees have experienced financial and monetary rewards as a source of unfairness[458], a form of bribery and negative control[459], and as a measure of the organization's or individual's performance instead of the project team's[460]. Particularly when innovation is organized as a team effort, it is difficult to divide the team's performance objectives into those of individuals[461] to assess individual contributions to the team's task[462] and to separate one project's activities from those of others. This is especially true in the front end of innovation, where individuals and groups typically develop several concepts simultaneously and often on a part-time basis. Collective rewarding encourages transferring the responsibility of control from top management to the work group itself, thereby reducing management's control influence[463]. Bonner et al. have concluded that the understanding of the influence of the reward system in the NPD context is still incomplete[464].

As the front end of innovation is the most uncertain part of the innovation process, its outputs are difficult to evaluate and measure objectively[465]. Monetary rewarding may thus lead to dysfunctional behavior and even decreased intrinsic motivation. Outcome-based rewarding may lead to reduced risk-taking behavior, thus causing a

[454] Sarin and Mahajan 2001, Bonner et al. 2002
[455] Sarin and Mahajan 2001
[456] Bonner et al. 2002
[457] Chester 1995
[458] Smith and Reinertsen 1998
[459] Amabile 1998
[460] Bonner et al. 2002
[461] Bonner et al. 2002, Imai et al. 1985
[462] Hertenstein and Platt 2000, Smith and Reinertsen 1998
[463] Imai et al. 1985, Merchant 1985
[464] Bonner et al. 2002
[465] See for example how Rockness and Shields 1988 and Ouchi 1979 in general classify the R&D in terms of outcome measurability.

lack of novelty of the developed product concepts. The part-time and group work nature of front end projects makes it impossible to fairly differentiate individual accomplishment from the final outcome. Finally, research results finding support that outcome-based rewarding contributes to increased performance mainly relate it to success measured in terms of quantity (i.e. number of outputs). It is quality and not quantity that is important at the end of front end, where the aim is to develop attractive product concepts for further development. Thus the following hypotheses are stated:

H3a: Outcome-based rewarding is negatively associated with product concept superiority.
H3b: Outcome-based rewarding is negatively associated with strategic renewal.

3.4 Strategic vision

Managers establish longer-term future aspirations in the form of a strategic vision or intent that is expected to guide activities in the front end of innovation. Strategic vision gives an overall direction to all organizational activities and products, and integrates individual accomplishments into the common goal[466], thus increasing the odds of success. As opposed to the more practical goal and task definition, strategic vision may entail value-laden choices of what is good and right for the firm[467], it creates a gap between the company's existing resources and capabilities and those required to achieve its intent[468], and decreases different interpretations of expected outcomes and increases the consensus on goals[469]. Companies with a clear, convincing and compelling vision of the general direction are able to move fast toward the desired goals[470]. If people are confident about future direction and viability they are willing to put in the extra effort to ensure that the company reaches the final aim[471]. This inspiration can be enhanced by articulating a compelling vision, allowing individual considerations of how employees can contribute to the vision and providing support for this effort[472]. However, the positive influence of strategic vision most

[466] McGrath 1996, Kotter 1990
[467] Barker 1993
[468] Schilling and Hill 1998
[469] Zhang and Doll 2001
[470] Englund and Graham 1999
[471] McGrath 1996, McGrath 2001
[472] Kotter 1990

likely emerges only from an adequately focused, clearly understood and feasibly interpreted vision.

A long-term strategic vision has been associated with better innovation performance. Clear vision helps to focus on the right issues, and remove unnecessary debate, contradictory directions and the confusion of appropriate direction, thereby increasing the odds of success[473]. Front end projects are cross-functional efforts and a strategic vision aligns critical decisions made in different functions and helps co-operation in situations that are typically hindered by communication shortages and misunderstandings. Zhang and Doll have discussed the meaning of shared team vision for a forthcoming innovation task and have suggested that a shared purpose and team vision would help in reducing task uncertainty (fuzziness) and would contribute to the success of front end teams[474]. A case study in a telecommunications company showed how the value-laden belief system affected a company's strategic climate which, in turn, acted as an idea filter by influencing which ideas were championed and which were disregarded[475]. McGrath, however, cautions about the dangers of "tunnel vision", i.e. taking too narrow a view of the future, which is an example of the difficulties associated with strategic vision as a control mechanism[476].The lack of understanding or commitment to the vision by the team easily leads to frustration, wheel spinning, and the disintegration of organizational activities[477]. Current theory seems to emphasize the positive influence, if appropriately defined, of a strategic vision on NPD activities. Therefore, the following hypotheses are stated:

H4a: Strategic vision is positively associated with product concept superiority.
H4b: Strategic vision is positively associated with strategic renewal.

3.5 Informal communication

Informal communication here refers to communication, information exchange and meetings that management informally uses to control front end projects. Informal reviews of actions, dialogue, hallway chats and meetings are an important part of

[473] McGrath 1996, McGrath 2001
[474] Zhang and Doll 2001
[475] Marginson 2002
[476] McGrath 2001
[477] Englund and Graham 1999

organizational control systems[478] and the climate for innovation[479], although they are barely touched upon in management control research. This may be due to the tacit nature of this control mechanism and the fact that there is not just one type of 'informal communication', which makes it otherwise difficult to conduct profound research in this field. Bisbe and Otley suggest that the complementary nature of informal and formal control mechanisms should encourage the use of both of these simultaneously[480]. Kirsch describes how informal information exchange such as e-mails, phone calls or meetings are used to supplement formal mechanisms in the implementation phase of information system development projects. She found that informal control modes dominated over formal methods in the requirements definition phase, i.e. the early phase of the information system development project.[481]

Due to the uncertainty in the front end of innovation, the importance of informal means of control to innovation success seems to be critical. Informal communication allows access to real-time and intangible information[482], it eliminates mistakes and suboptimal actions proactively[483], it enables managers to filter the information they consider as relevant[484], and promotes managers' prompt and timely contributions at the critical project points, including in key decisions and problem-solving situations[485] This active role of managers increases the motivation of developers as well as managers' confidence in the choices they make[486]. Harborne and Johne found that success of service development projects was associated with extensive informal communication between top management and development teams[487]. They emphasize that successful projects were characterized by top management's regular visits to the development teams and their promotion of a more open interpersonal communication style.

The current theory seems to agree that informal communication is used to supplement other formal control mechanisms. Agenda-free discussions enable information about

[478] Merchant 1985, Anthony, 1988, Cleland and King 1975
[479] Harborne and Johne 2003
[480] Bisbe and Otley 2004
[481] Kirsch 2004
[482] Anthony 1988
[483] Merchant 1985
[484] McGrath 1996
[485] Cleland and King 1975, McGrath 1996
[486] Smith and Reinertsen 1998
[487] Harborne and Johne 2003

specific, important development issues at hand to be shared quickly. This information helps to anticipate problems and ensure that critical decisions are adequately justified, and also to make corrective actions if needed. Again the above reviewed studies do not specifically address the front end phase of the innovation process, but deal with development projects in general. As the front end phase is the most chaotic and uncertain phase of the innovation process, informal communication as a control mechanism is expected to be particularly relevant. Typically informal communication between management and development personnel is scare. Thus it can be argued that increased informal communication has a positive influence on front end performance:

H5a: Informal communication between management and a front end group is positively associated with product concept superiority.
H5b: Informal communication between management and a front end group is positively associated with strategic renewal.

3.6 Participative planning

Management can involve employees in dealing with a particular issue through participative planning and to foster commitment to a forthcoming task. Senior managers use interactive control such as participative planning to break out of existing search routines, stimulate new opportunity seeking, and encourage the emergence of new strategic initiatives[488]. Bonner et al. have discussed participative planning in the NPD context as the interaction between management and project members during the formulation of project strategies, goals and procedures early in the project[489]. Participative planning provides explicit knowledge about goals to employees[490], can increase commitment, ownership and mutual understanding between management and the development group[491], decreases the need for other

[488] Simons 1995
[489] Bonner et al. 2002
[490] Fang et al. 2005
[491] Fang et al. 2005, Ramaswami 1996, Bonner et al. 2002, Schilling and Hill 1998, Sagie 1996, Smith and Reinertsen 1998

types of control[492], leads to more realistic goals[493], increases work satisfaction[494], and also decreases the dysfunctional behavior of employees[495].

The current understanding regarding participation in goal-setting and its influence on performance is somewhat conflicting. Some authors have found a positive relationship between participation and performance[496], whereas others have found this relationship non-existing[497]. Bonner et al. studied participative planning in the NPD context and agree that this increases the ownership and motivation of team members; they also emphasize that because members are typically knowledgeable of technical, functional and market challenges, there are greater possibilities of having realistic process and outcome standards. Further, they found that participation in operative-level matters was positively related to performance, but a similar association was not found in strategic-level decisions. Miller and Monge concluded in their meta study that participative decision-making, despite the conflicting findings, is indeed associated with productivity and work satisfaction, even though the first relationship is not so strong[498]. In particular, they argue that complex tasks benefit from participation more than simple ones. Situations where the problem or idea is poorly structured are generally regarded as suitable for participative decision-making because strong information input is needed from employees and solutions need to be accepted by employees to guarantee successful implementation[499]. In a similar vein, Kim and Mauborgne emphasize the importance of involving employees in strategic decisions pursuing "blue oceans", i.e. initiatives involving high market uncertainty. They argue that the benefits are two-fold; involvement leads to better management decisions and greater commitment from employees.[500] Participative goal-setting helps to increase the level of goal difficulty, which further positively affects performance[501]. Ylinen has found that interactive use of management control in general led to greater product

[492] Ramaswami 1996
[493] Bonner et al. 2002, Smith and Reinertsen 1998
[494] Miller and Monge 1986, Sagie 1996
[495] Ramaswami 1996
[496] Erez et al. 1985, Campbell and Gingrich, 1986
[497] Latham and Yukl 1976
[498] Miller and Monge 1985
[499] Manz and Sims 1980
[500] Kim and Mauborgne 2005
[501] Sagie 1996, Latham and Steele 1983, Ylinen 2004

innovativeness which, in turn, led to improved project performance in technical product development projects[502].

The earlier findings indicate that there are several positive effects of participative planning and that this is also associated with performance either directly or indirectly (first in the increase in the level of difficulty of the goals or product innovativeness and then in performance). In particular, the front end of innovation with fuzzy, poorly structured and complex tasks seems to be fertile ground for participative planning. Thus the following hypotheses are stated:

H6a: Participative planning is positively associated with product concept superiority.
H6b: Participative planning is positively associated with strategic renewal.

3.7 Intrinsic task motivation

Managers cannot alter employees' behavior directly, but they can use control mechanisms that promote employees' self-control and a voluntary change in behavior. The influence on employees' self-control and granted autonomy (from the management's point of view) may be intended or unintended. The issue of importance is the intrinsic task motivation caused by increased self-control[503]. This study focuses on examining the influence of intrinsic task motivation, which can be influenced by increasing empowerment and self-control. Management can promote self-control behavior by granting empowerment and autonomy for certain decisions, by using belief systems (showing vision, communicating values and inspiring individuals), deciding on only a broad direction or limitations for activities, cultivating the right organizational culture and working environment, giving appropriate feedback, communicating the value of self-control, and by offering training in the necessary self-control techniques[504].

NPD literature often emphasizes the positive aspects of self-control behavior[505]. Imai et al. have noted that autonomy facilitates creativity in problem solving and enhances

[502] Ylinen 2004
[503] Manz 1986, Thomas and Velthouse 1990, Luthans and Davis 1979
[504] Simons 1997, Imai et al. 1985, Mills 1983, Manz 1986, Kirsch 1996
[505] Pinnington and Haslop 1995, McGrath 1996, Wheelwright and Clark 1992, Tatikonda and Rosenthal 2000, Imai et al. 1985

team-based learning[506]. Tatikonda and Rosenthal have showed an association between project management autonomy and project success[507]. Smith and Reinertsen raise an important notion when stating that even imperfect decisions that are made quickly at lower organizational levels due to empowerment may be more valuable than slow, but perfect decisions, made at higher levels[508]. Existing theory seems to agree that especially in uncertain environments, the teams are the most knowledgeable about appropriate decisions and activities and are in the best position for controlling task accomplishment, and thus should be granted a considerable amount of autonomy and trust in their self-control capability.

Self-control is generally associated with several organizational advantages such as decreased supervision effort, increased flexibility, initiative, motivation, job satisfaction and commitment[509]. Findings concerning organizational effectiveness, however, are somewhat conflicting. Manz and Sims propose that self-control leads to increased effectiveness in the long run[510]. While Bailyn[511] argues that increased self-control improves performance in technical development teams, Henderson and Lee[512] do not find support for this hypothesis in the information system development project context. Another study found that self-management contributes positively to functional performance but not to cross-functional performance[513].

Self-control is frequently recommended in uncertain activities, non-routine and complex tasks, tasks requiring creativity and intellectual activities, and in the early phase of the innovation process[514]. If a person feels meaningfulness in the task, feels the opportunity to make a difference, has the competence and can make behavioral choices, that person is intrinsically motivated for the task[515]. In other words, there is "passion and interest – a person's internal desire to do something"[516]. This motivation further energizes, sustains individual behavior and produces commitment and

[506] Imai et al. 1985
[507] Tatikonda and Rosenthal 2000
[508] Smith and Reinertsen 1998
[509] Manz and Sims 1980, Thomas and Velthouse 1990, Uhl-Bien and Graen 1998
[510] Manz and Sims 1980
[511] Bailyn 1985
[512] Henderson and Lee 1992
[513] Uhl-Bien and Graen 1998
[514] Mills 1983, Govindarajan 1988, Otley 1994, Kirsch 1996, Kirsch 2004
[515] Thomas and Velthouse, 1990, Manz, 1986
[516] Amabile 1998 p. 79

satisfaction. Further, this intrinsic task motivation is associated with increased performance through its impact on effort and persistence[517]. Based on the above, the following hypotheses are put forward:

H7a: Intrinsic task motivation is positively associated with product concept superiority.
H7b: Intrinsic task motivation is positively associated with strategic renewal.

3.8 Moderating effect of market and technology uncertainty

Empirical studies have considered the degree of project uncertainty or product innovativeness as a moderator between management–performance relationships[518]. Emphasis has been on the degree of change pursued by the project. The front end of innovation is uncertain and even chaotic in itself (both in terms of product and project), but it faces uncertainties also from its external technological and market environment. Previous research calls for a fit between internal and external resources, i.e. a firm's competences and activities must be aligned with the uncertainties in the environment for the innovation to succeed[519].

Routine, structured and independent tasks have been considered as suitable for instituting formal process control[520], whereas an increase in task uncertainty should cause a reduction in formalization and an increase in decentralization[521]. Organic structures, i.e. decentralized and informal structures, provide greater capacity for information processing compared to mechanistic structures and are therefore more suitable for uncertain environments[522]. Lawrence and Lorsch were among the first to link this causality into performance, finding that the situation (e.g. a research lab) where high task uncertainty was associated with low formality and low centralization led to higher performance[523]. The more the front end group is able to reduce uncertainty, i.e. close the gap between the required and possessed information about user needs, technology, competition, and the required resources, the higher the

[517] Manz 1986, Thomas and Velthouse 1990
[518] Salomo et al. 2007b, Bonner et al. 2002, Eisenhardt and Tabrizi 1995
[519] Danneels and Kleinschmidt 2001
[520] Burns and Stalker, 1966, Ouchi, 1979; Eisenhardt 1985
[521] Donaldson 2001 p. 29; Lawrence and Lorsch, 1967, Fry and Slocum 1984
[522] Burns and Stalker 1966
[523] Lawrence and Lorsch 1967

possibility to make a commercially successful product.[524] Successful uncertainty reduction in the front end phase decreases the need for change in later phases of the innovation process, resulting in higher product development success. The empirical findings of Kirch[525] indicate that practitioners apply this rule, either consciously or unconsciously, by using formal mechanisms more intensively in the implementation phase (project phase) of the innovation process and informal mechanisms in the early requirements definition phase. In particular, the literature focusing on radical innovations[526] emphasizes the critical role of product innovativeness in determining appropriate management practices in a development process.

Prior research indicates that increased technology and market uncertainty reduces the usefulness of process formalization. Previously, the front end of innovation has been discussed along with any NPD project, but it is believed that the front end phase, which includes even more uncertainty than the development project phase, is not suitable for process formalization. Development of superior product concepts and the contribution to strategic renewal in uncertain environments requires that new information is acquired, learning through trial-and-error is allowed, and new opportunities are pursued without interruptions. This may call for free-wheeling, iteration, quick and remarkable reactions to attractive opportunities, and autonomy. The sequence of activities cannot be foreseen, nor should it be enforced based on previous projects. Autonomously working NPD teams have been found to contribute to project performance especially in innovative and uncertain projects, not in incremental projects[527]. In turn, formalized processes and excess bureaucracy hinders and slows down adaptation capabilities and the exploration of different alternatives[528]. Front end groups working under high uncertainty should be protected so that the concepts have a chance to incubate and develop, e.g., by being provided with isolated environments within the organization to minimize the distractions and pressures. It has even been recommended that the teams are spun off from the conventional internal organization[529]. Hypotheses H2a and H2b stated that front end formalization is negatively associated with front end performance. In the case of high market or

[524] Moenaert et al. 1995
[525] Kirch 2004
[526] E.g. McDermott and O'Connor 2002, Gemünden et al. 2007, Simon et al. 2003, Stringer 2000
[527] Griffin 1997, Olsson et al. 1995
[528] Stringer 2000
[529] Simon et al. 2003

technology uncertainty, the negative consequences of process formalization are even more likely to overcome the potential advantages of formalization. Therefore, the following hypotheses:

H8a: The more market uncertainty, the more negative the association between front end process formalization and product concept superiority.
H8b: The more technology uncertainty, the more negative the association between front end process formalization and product concept superiority.
H8c: The more market uncertainty, the more negative the association between front end process formalization and strategic renewal.
H8d: The more technology uncertainty, the more negative the association between front end process formalization and strategic renewal.

The more uncertain the market and technology environment, the more difficult it is to objectively and accurately assess certain outcomes and the less appropriate are outcome-based rewards. High front end performance in uncertain environments will require sensitivity of the front end group toward events in the environment. As mentioned, outcome-based rewarding may lead to reduced risk-taking behavior, which is necessary for superior concepts and strategic renewal in an uncertain environment. Sarin and Mahajan explained that under high risk conditions, NPD teams working in a risk-averse mode and the amount of risk they are willing to bear is low[530]. Further, they found that trusting outcome-based rewarding in these conditions leads to lower performance. It may also delimit the front end group's search span to strategically familiar areas[531] and thereby promote avoidance of uncertainty.

As mentioned earlier, the inappropriate use of outcome-based rewarding has been associated with dysfunctional behavior, decreased intrinsic motivation, hampered creativity, reduced risk-taking behavior, and poorer performance[532]. Based on this reasoning, hypotheses H3a and H3b stated that outcome-based rewarding is negatively associated with front end performance, and since the increased market and

[530] Sarin and Mahajan 2001
[531] E.g. Kim and Mauborgne 2005
[532] Bartol and Srisastava 2002, Sarin and Mahajan 200, Jenkins Jr. et al. 1998, Amabile et al. 1996, Ramaswami 1996, Simons 1995, Snell 1992

technology uncertainty make conditions of using outcome-based rewarding even worse, the following hypotheses are made:

H9a: The more market uncertainty, the more negative the association between outcome-based rewarding and product concept superiority.
H9b: The more technology uncertainty, the more negative the association between outcome-based rewarding and product concept superiority.
H9c: The more market uncertainty, the more negative the association between outcome-based rewarding and strategic renewal.
H9d: The more technology uncertainty, the more negative the association between outcome-based rewarding and strategic renewal.

3.9 Summary of hypotheses

Based on the review of the existing literature, altogether 22 hypotheses related to the association between the use of management control mechanisms and front end performance have been made. Figure 2 shows 11 hypotheses that were developed to investigate the influence of control mechanisms on product concept superiority. Seven of these hypotheses (H1a–H7a) concern the direct relationship between the use of the control mechanism and the performance. Four other hypothesize (H8a, H8b, H9a and H9b) a moderated relationship where market uncertainty and technology uncertainty are used as moderating variables. Figure 3 shows 11 hypotheses that were made to investigate the influence of control mechanisms on strategic renewal. Again, seven of these hypotheses (H1b–H7b) concern the direct relationship between the use of the control mechanism and strategic renewal and four hypotheses (H8c, H8d, H9c and H9d) a moderated relationship. The following chapter presents the hypothesis testing methods.

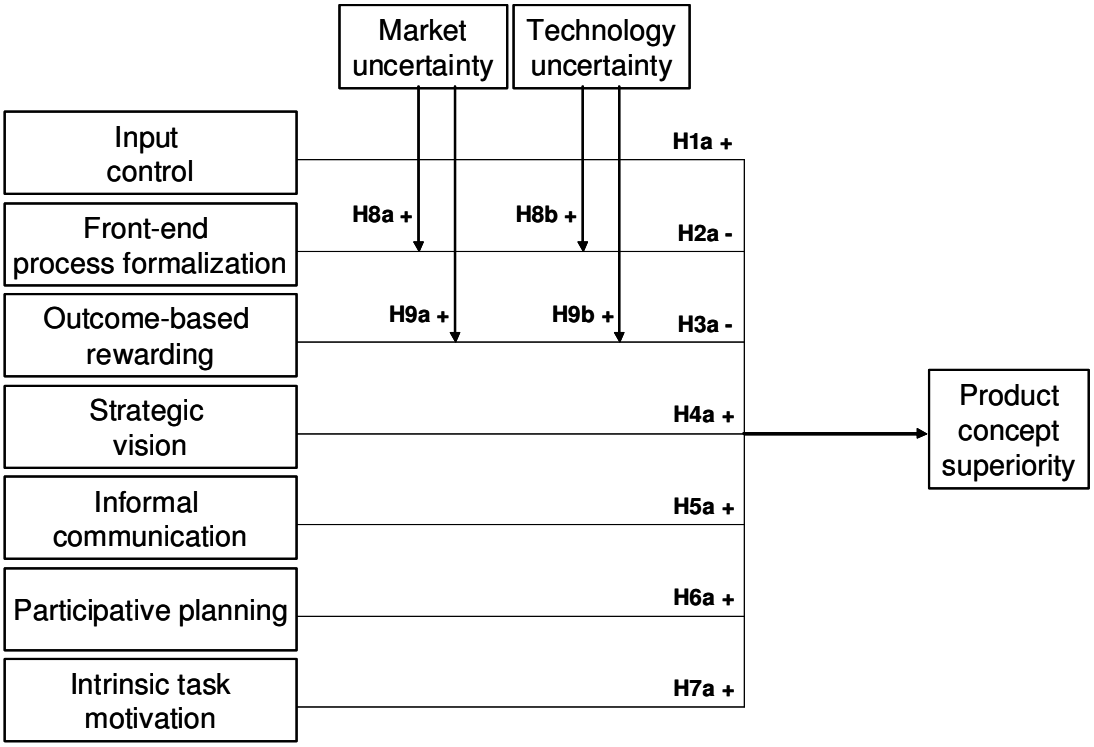

Figure 2. Measurement model for product concept superiority.

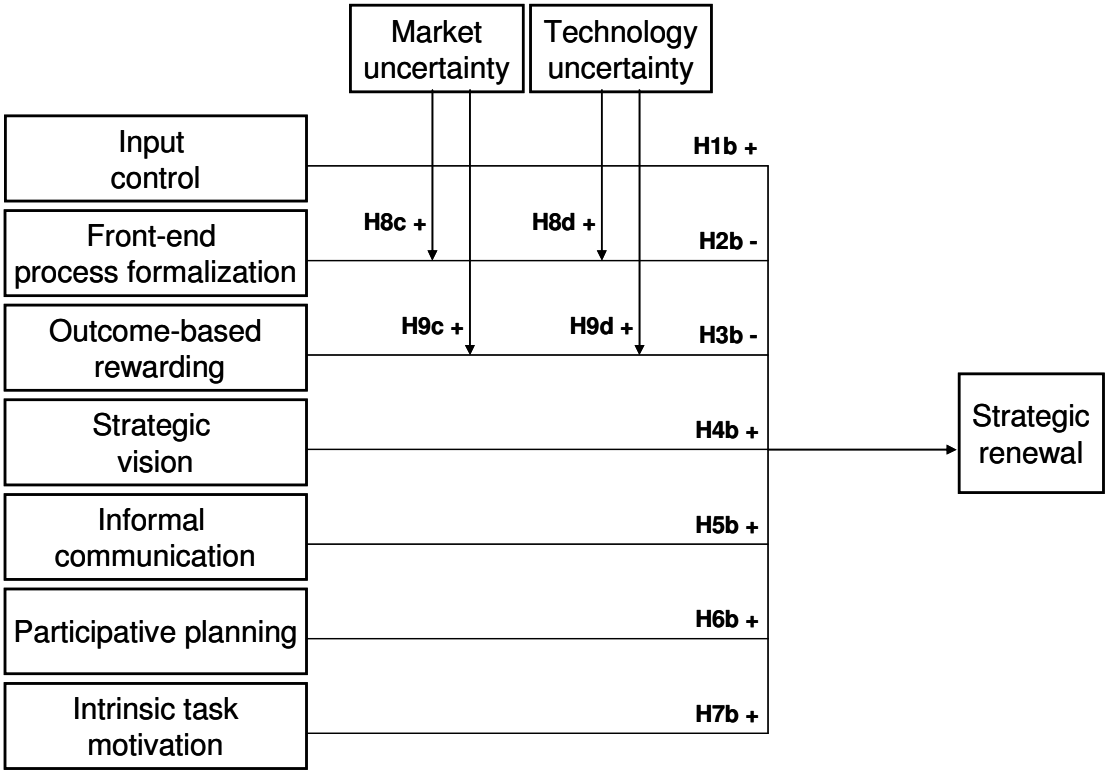

Figure 3. Measurement model for strategic renewal.

4 HYPOTHESES TESTING METHODS

***"Science is the attempt to make the chaotic diversity of our sense-experiment correspond to a logically uniform system of thought. In this system single experiences must be correlated with the theoretical structure in such a way that the resulting co-ordination is unique and convincing."* – Albert Einstein**

This chapter presents the research methods used in this dissertation. The first subchapter describes the sample used in this study. The second subchapter illustrates the survey design of the study. The third subchapter discusses the statistical methods applied in the data analysis. The fourth subchapter illustrates how the measurement constructs were operationalized. Finally, the chapter concludes with a discussion of the reliability and validity of the research methods used.

4.1 Population and sample

The sample of companies was taken from the BlueBook database[533], which holds information for all Finnish industrial companies. Two selection criteria were used:

1. Companies have more than 50 employees.
2. Companies carry out product development activities.

Different business units of the 50 biggest Finnish companies (based on turnover figures in 2004) fulfilling the above criteria were also included in the research in order to increase the appropriate population of the study. These companies are relatively big corporations and the control practices between different business units were expected to vary. In total, 888 companies[534] fulfilling these criteria were found from the database. A questionnaire was sent to all these companies, i.e. to the whole population, in December 2005. The questionnaire was addressed to the R&D director, research director, technology director, CEO, BU director or R&D-responsible person in each company. The people holding these titles were considered as the key informants in a position of controlling front end projects from the management's point of view. It was expected that medium-sized companies especially have manager-level employees (an R&D-responsible person) with have responsibility for controlling the company's NPD activities. In addition to the contact information found from the

[533] TDC Hakemistot Oy Blue Book. http://yrityshaku.bluebook.fi
[534] Company in this context refers also to different business units of the 50 biggest Finnish companies.

BlueBook database, the Technology Industries of Finland membership catalogue 2005[535] and, in unclear cases, a phone call was used to find an appropriate contact person for the survey.

4.2 Survey design

The empirical data of this study was gathered through a survey administrated to the whole population of the companies.

4.2.1 Questionnaire

The survey questionnaire was constructed based on the thorough analysis of the relevant literature presented in previous chapters. The survey questionnaire was eight pages long and divided into two parts. The first part focused on the background information of the company, also including questions related to the background of the respondent. The second part focused on the front end project itself, which was a unit of analysis in this study. The respondent was asked to select the most recent significant product development project (independent of its success or failure) where the front end phase was already completed. Respondents were asked to answer the questions based on this example front end project.

The questions covered different control mechanisms (independent variables), front end performance measures (dependent variables), and also some contextual information regarding the front end project. In addition, some key figures of the company such as turnover were requested at the end of the questionnaire. The questionnaire included 48 main questions in total. However, these questions additionally included sub questions, resulting in a total of 130 individual questions.[536]

The majority of questions were multiple choice questions in which the respondent was asked to choose an appropriate answer. Two measurement scales were used. The first scale measured items on a typical five-point Likert scale with the options strongly disagree, somewhat disagree, do not agree or disagree, somewhat agree, and strongly agree. The other scale measured items by focusing on the extent to which a certain issue was applied in the front end project. The options were not at all, to a little extent,

[535] Technology Industries of Finland membership catalogue 2005
[536] The questionnaire included many questions but only part of these questions is used in this thesis.

to some extent, to a great extent, to a very great extent. In addition, all scales included a "do not know" option for those informants who were unable to answer the question. The questionnaire took approximately 30–40 minutes to complete. The language of the survey form was Finnish.

The name of the respondent was asked at the end of the questionnaire to enable the delivery of the following advantages: 1) a free front end seminar based on the results of the research project, 2) a summary of the survey results, and 3) a book focusing on front end issues based on the results of the research project. Confidentiality was emphasized in this section and contact information was asked for only if the respondent found some of the above advantages attractive. Only nine (6.6%) of the respondents refused to give their contact information and so anonymity was not a problem. In addition, 92% of respondents requested on or more of the three benefits promised, which illustrates the motivation to participate in this survey.

Before sending the questionnaire it was tested both with academics and practitioners. As suggested by Fowler[537], the questions designed were subjected to a critical systematic review. The questionnaire was discussed with four experienced researchers including the instructor and the supervisor of this thesis. The purpose was to improve the wording of the questions and increase their accuracy, understandability and validity. In addition, the questions were discussed with a survey research expert from the methodological point of view. The improved questionnaire was field pre-tested with five practitioners representing different companies[538]. Practitioners filled in the questionnaire, which was followed by a short interview with the purpose to clarify whether the questions were clear, understandable and relevant, whether the survey covered all relevant areas under the investigated phenomena, as well as whether the instructions to answer the questionnaire were clear. Field tests lead to minor modifications of some questions, but also to one unclear question being changed for a better one.

[537] Fowler 2002
[538] Ibid.

4.2.2 Mailing process

The communication process included three separate types of contact with the company representatives. First contact was made via mail and consisted of a cover letter (Appendix A) emphasizing the importance of the survey, response instructions (Appendix B), the eight-page questionnaire (Appendix C), and a pre-paid return envelope. This package was addressed to the 888 respondents personally. The cover letter included a definition of a suitable respondent; if the addressee was not in the required position, the person was advised to forward the survey to the right person in the organization. Three weeks after the mailing, a second contact was made as suggested by Dillman[539]. This was done with an e-mail reminding the respondent about the survey. A different contact method was used to make contact effective with non-respondents more effective[540]. The e-mail also included an electronic copy of the survey as well as a link to the electronic version of the questionnaire on the web. Final contact was made by a phone to 50 randomly selected non-respondents to increase the sample size.

The questionnaire was sent to 888 respondents. A total of 21 companies indicated that they did not carry out product development activities or the questionnaire was returned because the respondent was no longer with the company. This resulted in a maximum sample of 867 companies. Of these companies, 137 returned the completed questionnaire, which leads to a response rate of 15.8%. The response rate can be considered as acceptable in the light of the long questionnaire and the fact that the questionnaire was targeted toward the director-level group where time resources are always scarce. Out of the 137 returned questionnaires, three companies participated in the survey with two business units, and in addition the respondents indicated that they had a company-wide approach to controlling front end projects. One business unit was randomly selected from each of these three pairs and removed from the final sample as inclusion of both business units in these pairs would have naturally biased the sample[541]. In addition, one uncompleted answer was removed because the returned questionnaire included only 26% of the requested data. The final usable sample for statistical testing was 133.

[539] Dillman 2000
[540] Ibid.
[541] Birnberg 1988

When surveys rely on the responses of a single informant, special attention should be paid that the informant is knowledgeable in the survey domain[542]. Even though controversial opinions of applicability of a single informant have been presented[543], it was considered to be a suitable approach in this study. The questionnaire was sent to the R&D director, research director, technology director, CEO, BU director or R&D-responsible person in each company, who were considered to be the key informants in the investigated phenomenon. As can be seen from Table 7, the great majority of respondents (92.5%) held one of these positions. The respondents had 5.7 years of experience (range: 0–30) in their position on average and 12.8 years of experience (range: 0–40) in the organization on average.

Table 7. Organizational position of respondents.

Position	Number of respondents	Percentage
R&D Director, Development Director, Research Director	52	38.8%
R&D Manager, Research Manager, Development Manager	34	25.4%
CEO, BU Director	20	14.9%
Technology Director, Technical Director	17	12.7%
Others	10	7.5%
Total	133	100.0%

4.2.3 Missing value analysis

Only 1.56% of the data of used measurement items were missing, which indicates that the returned questionnaires were completed thoroughly. The missing values were visually inspected to find possible patterns of missing data, but no such patterns were found. The influence of missing data seemed to be insignificant and random. In a few cases, the answer was unclear and it was impossible to correctly interpret it. In these cases, the answer was left blank. Some respondents presented answers as a range (e.g. 1–3) in some descriptive background questions. In these cases, the average figure was used. Listwise exclusion of data was used in the case of missing data.

[542] Campbell 1955, John and Reve 1982
[543] See e.g. Phillips 1981

4.2.4 Non-response analysis

A potential problem in mail surveys is the possibility of bias that results from low response rates[544]. The response rate in this study was 15.8%, which is reason to study a possible response bias. One method to investigate the response bias is to compare early and late respondents of the survey[545]. Armstrong and Overton have suggested that late respondents, who responded because of the increased stimulus, are relatively similar to non-respondents[546]. Possible response bias was analyzed by testing a difference in turnover, number of employees and R&D intensity (percentage of turnover to R&D) between early (63 companies) and late (70 companies) respondents. The results of this test are presented in Table 8. No statistically significant differences were found between early and late respondent groups. The results indicate that response-bias is not a problem in this study and the sample can be considered to be representative of the target population (see Chapter 4.5.2). This supports the findings of Krosnick, who concluded that a low response rate does not necessarily mean that a survey includes a non-response error[547].

Table 8. Independent sample t-test of difference between early and late respondents in terms of selected variables.

Analyzed figures	Early respondents (N=63) Mean (Std. Dev.)	Late respondents (N = 70) Mean (Std. Dev.)	t	df	Sig. (2-tailed)
Turnover	1661.55 (5258.80)	391.79 (780.84)	1.88	63.38	.06
% of turnover to R&D	5.11 (12.93)	9.53 (28.37)	-1.11	86.23	.27
Number of employees	5412.97 (15617.33)	1982.57 (4514.20)	1.68	71.31	.10

4.3 Statistical methods

Two main statistical methods are used in this study. First, an exploratory factor analysis was applied to test the validity and undimensionality of a priori-created constructs. Cronbach's inter-item coefficient alpha was calculated for each factor variable to evaluate the reliability of the measurement construct. Second, a multiple linear regression analysis was used to test the hypotheses that were made.

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[544] Fox et al. 1998

[545] Note that the unit of analysis was an example front end project, not a company. However, examining response bias based on the company figures give some indication of the representativeness of the target population.

[546] Armstrong and Overton 1977

[547] Krosnick 1999

4.3.1 Exploratory factor analysis

Exploratory factor analysis is favored in this study over confirmatory factor analysis since the verified management control measurement constructs applied in the front end context and front end performance measurement constructs are scarce. Factor analysis is a method to analyze interrelationships (correlations) among a large amount of different variables and to explain these variables in terms of their common underlying dimensions, know as factors. These factors are often called hidden or latent constructs[548]. The purpose of factor analysis is to compress the information included in original variables into a smaller amount of factors with a minimum loss of information[549].

This study applies principal component analysis as a factor extraction method. Principal component analysis aims at finding a linear combination of variables in such a way that the maximum variance is extracted from the variables. In principal component analysis, all the variance is included in the analysis including a common variance (a variance in a variable shared with all other variables), a specific variance (a variance associated only with a specific variable), and an error variance.[550]

Latent root criterion is the most commonly applied technique in factor extraction. The idea behind the latent root criterion is that any individual factor should explain more variance than a single variable in order to be acceptable. This criterion can be measured in terms of eigenvalues which should be at least one (1.0) to be considered significant.[551] This study applies eigenvalues to confirm that the number of factors found from the empirical data and the number of theoretically derived constructs correspond to each other.

Factor loadings above .50 were retained in the final factor solution in this study. Factor loadings refer to the correlation between each original variable and the factor. Generally, factor loadings greater than +/- .30 are considered as the minimal acceptable level and loadings +/- .50 as practically significant[552]. Hair et al. find that

[548] Dewberry 2004
[549] Hair et al. 1998
[550] Ibid.
[551] Ibid.
[552] Ibid.

factor loadings of .45 are needed with a sample size of 150 for statistical significance (.05 significance level)[553].

The varimax rotation technique was applied in this study to make the factor solution more interpretable. There are two alternatives to rotate the factors: orthogonal or oblique rotation. Orthogonal rotation techniques such as Varimax rotation are more widely applied compared to oblique methods[554]. Varimax rotation results in a factor solution where factors are uncorrelated with each other (i.e. mathematically, factor axes are maintained at 90 degrees). This leads to an easily identified factor solution where a specific variable load is high in one factor and low in all the other factors.

Two tests can be used to evaluate the suitability and adequacy of empirical data for factor analysis. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (MSA) is a statistic that indicates the proportion of variance in variables that is caused by underlying factors. Hair et al. suggest that an MSA higher than .80 is meritorious, above .70 is middling, above .60 is mediocre, and lower than .60 is unacceptable[555]. Bartlett's test of sphericity tests the hypothesis that the correlation matrix is an identity matrix, which would indicate that variables are unrelated and the factor model is inappropriate. Values below .05 of the significance level indicate that a factor analysis is appropriate. In addition, the total variance explained by the factor combination gives some indication of the appropriateness of the factor solution. The sample size, MSA and total variance figures explained are reported in each factor analysis.

Due to the prevailing debate of the suitability of using principal component analysis or principal factor analysis in finding the appropriate factor solution, the factor analysis was confirmed by testing the independent variable structure using principal factor analysis with the Maximum-Likelihood method and Oblimin with the Kaiser normalization rotation technique[556]. The results indicated that the factor solution remained the same, the total explained variance of the factor solution remained the same, and only the loadings of individual variables somewhat decreased. Chi-square statistics indicated that the created factor model fit the data (Chi-Square = 65.54, df =

[553] Hair et al. 1998
[554] Ibid.
[555] Ibid.
[556] See e.g. Hair et al. 1998

84, Sig. = .93). The chi-square fit tests the difference between the original and predicted covariance matrix based on the specified common factor model. The null hypothesis of the chi-square test is that the factor analysis model fits the data and thus the non-significant chi-square statistic indicates the specified factor model cannot be rejected.

Exploratory factor analysis was complemented by calculating internal consistency coefficients for variables included in measurement models. This internal consistency reliability is indicated in the form of Cronbach's coefficient alpha, which measures reliability among a group of items combined to form a single scale. Internal consistency of identified factors is discussed in more detail in Chapter 4.5.1.

Based on the results of the exploratory factor analysis, items of each individual factor were transformed as a summated scale by taking an average of items belonging to the same construct. These average scales were used representing the variables in the regression analyses.

4.3.2 Multiple linear regression analysis

Multiple linear regression analysis was used to test the created hypotheses. Regression analysis is a statistical technique to analyze the relationship between a single dependent variable and several predictor (independent, explanatory) variables. The multiple linear regression equation in its general form can be presented as the following: $Y_j = B_0 + B_1X_{1j} + B_2X_{2j} + \ldots + B_nX_{nj} + E_j$. Y_j are the values of the dependent variable, B_0 is a constant, $X_{1j} - X_{nj}$ are independent variables, $B_1 - B_n$ are the regression coefficients for $X_{1j} - X_{nj}$, and E_j is an error term representing residuals from fitting the regression line to the different data observations. This study applies ordinary least squares regression (OLS), which is the most often applied regression analysis method. In OLS regression, the values of regression coefficients are estimated to minimize the sum of squared residuals of prediction, i.e. the distance between the observed data points and the corresponding points on the regression line is minimized[557].

[557] Cohen and Cohen 2003

Assumptions

The use of multiple linear regression analysis is based on several assumptions that the empirical data and the investigated phenomenon must fulfill. These are 1) linearity of the phenomenon measured, 2) normality of the error term (residual) distribution, 3) constant variance of the error terms, 4) independence of the error terms, 5) low multicollinearity, and 6) sufficient sample size.[558] In addition, the multiple regression analysis is only able to handle metric data. Thus the categorical data was transformed to the metric by creating dummy variables in this study.

The first assumption, linearity of the phenomenon measured, means that the relationship between the dependent and independent variable should be linear. This linearity refers to the degree to which the change (the regression coefficient) in the dependent variable is constant across the range of values for the independent variable. If any curvilinear pattern is found, data transformations should be used.[559] The linearity was investigated by creating a scatter plot for each pair of dependent and independent variables and fitting a linear line to this scatter plot. The investigation of these scatter plots did not reveal any non-linear relationships.

The second assumption requires error terms to be normally distributed. This concerns independent variables especially[560]. There are two alternatives detecting normality assumptions. The simplest diagnostic tool is a histogram of residuals (error terms), which can be visually checked for whether a distribution is approximately normal. The other way is the use of normal probability plots where the standardized residuals are compared with a normal distribution. The residual line closely follows a straight diagonal line, which represents a normal distribution if a distribution is normal.[561] This study applied both a histogram of residuals and normal probability plots to analyze the normality of error terms. No indication of non-normality was found.

Thirdly, error terms should have a constant variance. The presence of unequal variance causes heteroscedasticity, which is one of the most often violated assumptions in linear regression analysis. Heteroscedasticity can be investigated by

[558] Hair et al. 1998, Cohen and Cohen 2003, Nummenmaa et al. 1997
[559] Hair et al. 1998, Cohen and Cohen 2003
[560] Cohen and Cohen 2003
[561] Hair et al. 1998

using the Levene test, which measures the equality of variances for a single pair of variables. There are two alternative remedies for heteroscedasticity. If the violation occurs only in one independent variable, the weighted least square method can be applied.[562] The other option is to use other variance-stabilizing transformations such as the White correction. The Levene test was conducted for each pair of variables and no signs of heteroscedasticity were found.

The fourth assumption concerns the independency of error terms. Error terms of the observations must be independent of each other, i.e. cannot be sequenced by any variable. Typically, any random sample from a population fulfils this criterion.[563] Independency of error terms can be investigated by plotting the residuals against any possible sequencing variable. Independent error terms are seen as a random pattern in a residual plot. Data transformations and the inclusion of control variables can be used to overcome this violation.[564] In this study, several control variables such as firm size, R&D intensiveness, front end intensiveness, industry sector and objectives of the front end project were used to ensure the independency of error terms.

The fifth assumption requires low multicollinearity among independent variables. In the case of multicollinearity, the same variation is inserted in the regression model at more than one time. This makes it difficult to define the influence of each independent variable.[565] Hair et al. state that the presence of high correlation (.90 or more) is one indication of high collinearity. Lack of high correlation, however, does not guarantee the lack of collinearity, which may be caused by the combined effect of other independent variables. There are two common measures typically used to evaluate multicollinearity: 1) the tolerance value and 2) the variance inflation factor (VIF). These measures indicate to which extent each independent variable is explained by the other independent variables. Thus a small tolerance value and high VIF value reflects high collinearity. Typically applied cut-off values are .10 for the tolerance value and 10 for the VIF value, indicating serious multicollinearity problems.[566] All the VIF values of independent variables without interaction terms were found to be

[562] Hair et al. 1998
[563] Cohen and Cohen 2003
[564] Hair et al. 1998
[565] Nummenmaa et al. 1997
[566] Hair et al. 1998

below 2, the highest being 1.42. This indicates that multicollinearity is not a problem in this study.

Finally, the sample size should be sufficient to ensure the appropriateness of using multiple regression analysis and adequate statistical power[567]. With small sample sizes, only very strong associations can be detected with certainty. On the other hand, very large samples (over 1000 observations) make statistical significance tests too sensitive. Hair et al. give a general rule that there should be at least five times as many observations as there are independent variables in total in order to avoid 'overfitting' the model and causing problems of generalizability.[568] This study follows the above recommendations.

Interpreting the regression model

The standardized coefficients (Beta values b_k) indicate the relative importance of independent variables, i.e. how much they uniquely account for the variance of the dependent variable. The bigger the Beta value on a scale of 0–1, the more important the independent variable. The t-test is used to examine whether the variance explained by each independent variable is statistically significant. The t-value indicates how many standard errors the coefficient is from zero. The probability value p in turn indicates the significance of the test that b_k is different from zero. For statistical significance, the p-value needs to be below .05.[569]

R values indicate the overall explanatory power of the regression equation. The R value is the multiple correlation between the independent variables and the dependent variable. The R^2 value shows the percentage of variance in the dependent variable that the independent variables collectively account for.[570] However, the R^2 value is influenced by the number of different independent variables relative to sample size in the regression equation. Thus the adjusted R^2 value, which takes into account the number of independent variables and the sample size, is typically used to measure explanatory power, i.e. goodness of fit, of the overall regression equation.[571] Statistical significance of the overall regression equation is indicated by the F value of

[567] Nummenmaa et al. 1997, Hair et al. 1998
[568] Hair et al. 1998
[569] Dewberry 2004
[570] Ibid.
[571] Hair et al. 1998

the analysis of variance. If the F value is below .05, the null hypothesis that there is no association between the independent variables and the dependent variable can be rejected.[572] Beta values, p-values, R values, R^2 values and F values are reported in each regression analysis.

Moderating effect

The moderating effect of market uncertainty and technology uncertainty on two independent variables (front end process formalization and outcome-based rewarding) was tested. The moderating effect (interaction effect) means that an independent variable (C) changes the form of the relationship between another independent (A) and dependent variable (B), as presented in Figure 4. The moderating effect can be presented in a regression equation simply by multiplying an independent variable by the moderating variable. The moderating effect is investigated by first estimating the original, unmoderated regression equation. Second, the moderated relationship is estimated. Third, the change in R^2 between these two equations is investigated. A statistically significant change in R^2 value indicates a significant moderating effect.[573]

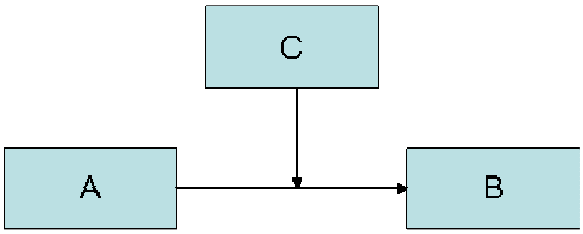

Figure 4. Moderating effect of C on the relationship between A and B.

Predictor value centering was used to investigate interaction terms in this study in order to avoid problems of multicollinearity caused by interaction[574]. Centering means that a predictor value is linearly transformed into a new variable with an average of zero, i.e. the mean of the predictor value is subtracted from each score of the predictor. According to Lance, a centering provides the following advantages: 1) multicollinearity among predictors is reduced, 2) interaction and main effects are

[572] Dewberry 2004
[573] Hair et al. 1998
[574] Cohen and Cohen 2003

separated, and 3) a regression coefficient for the residual cross-product term is directly interpretable[575].

4.4 Measurement construct operationalizations

This study applies existing, validated measurement constructs as much as possible. However, as mentioned earlier there are not so many empirical quantitative studies that have investigated management control in the front end of innovation in a holistic manner. Thus, new measurement constructs needed to be created. Two principles for creating new measurement constructs were applied. First, the new measurement construct was based on modifying existing and validated measurement constructs from another context if a close proxy was found. Second, when a new measurement construct was created from scratch, it was based on extensive literature analysis. The measurement of dependent variables and the moderating variables "market uncertainty" and "technology uncertainty" was based on the opinions of respondents on a Likert scale from one to five. Independent variables (other than "intrinsic task motivation" and "strategic vision" constructs where the Likert scale was used) were measured on a scale of one to five with the respondents judging the intensity of which different control mechanisms were used in the particular front end project. Control variables are based on exact company figures and simple categorical questions.

4.4.1 Performance variables

Two performance variables were used in this thesis: "product concept superiority" and "strategic renewal". The measurement was done from a single front end project level. The items were measured with a five-point Likert scale (1 = strongly disagree…5 = strongly agree). Measurement of success in the product innovation context is a complex and difficult task. Because of success measurement criticalness, much attention is devoted to clarifying appropriate success measures[576]. The guiding principle for developing a product concept superiority variable for the front end of innovation context was to modify those validated performance variables that have been used to measure product advantage in NPD studies, which further have been

[575] Lance 1988
[576] See e.g. Griffin and Page 1996 discussing of results of International Product Development Management Association's (PDMA) success measurement project.

associated with product performance in the market in several studies[577]. Product concept superiority is adopted from Cooper, who studied over 1000 new products and their development process with the aim of finding the drivers of successful product innovations. The number one success factor in his study was a unique and superior product. A product with unique attributes, superior price/performance characteristics, and high customer satisfaction has greater chances of success in the markets.[578] Similar measurement items have also been applied by Shenhar et al, who named this success dimension as the "impact on customer"[579]. Items for this product concept superiority construct were collected and modified based on items used by Cooper[580], Griffin and Page[581], and Song and Montoya-Weiss[582], who used these measurement items in the product development project context, by Shenhar et al.[583], who recommend these items in the project context in general, and especially by Herstatt et al.[584] and Kleinschmidt et al.[585], who applied similar items in studying front end performance. The product concept superiority construct consists of five items, two of them dealing with the product's comparative position to competitors' products, one concerning the potential competitive advantage created by the product, and two items related to the impact on customers.

Many of the project advantages cannot be realized immediately but merely help the company to confront business challenges in the future. Shenhar et al. stated that "preparing for the future", including measures such as the level of creating new markets or developing new technologies, is good especially in assessing the success of highly sophisticated technology projects[586]. Evidently, many of the items measuring the capability of renewing the existing knowledge base, capabilities or business can be associated with more radically oriented projects. Measurement items for this strategic renewal construct were collected and modified based on items used by Shenhar et

[577] Calantone et al. 2006, Veldhuizen et al. 2006, Cooper and Kleinschmidt 1987
[578] Cooper 1994
[579] Shenhar et al. 2001
[580] Cooper 1994
[581] Griffin and Page 1996
[582] Song and Montoya-Weiss 2001
[583] Shenhar et al. 2001
[584] Herstatt et al. 2004
[585] Kleinschmidt et al. 2005
[586] Shenhar et al. 2001

al.[587], who recommend these in the project context in general, Cooper and Kleinschmidt[588], who used these items in the product development project context, and especially by Herstatt et al.[589] and Kleinschmidt et al.[590], who applied these items in studying front end performance. The strategic renewal variable consists of four items. The first two items measure the extent to which a new product concept helps to create new markets or open up NPD opportunities for the company. The last two items measure the level to which the development of the product concept increased know-how in terms of both technology and markets.

Table 9 illustrates factor loadings for these two performance variables. Two different factors with a clear factor solution and high loadings were found as expected. Bartlett's statistic is significant, MSA is .68, and the factor solution explains 52% of total variance. Cronbach's inter-item coefficient alpha for the product concept superiority variable is .69 and the strategic renewal variable .76.

[587] Shenhar et al. 2001
[588] Cooper and Kleinschmidt 2000
[589] Herstatt et al. 2004
[590] Kleinschmidt et al. 2005

Table 9. Measurement items and factor loadings for product concept superiority and strategic renewal variables.

Measurement items	Factor 1	Factor 2
The product, which is based on the developed product concept, will…		
Product superiority		
…provide unique features for the customers compared to the competitors' products.	.25	**.65**
…achieve a superior price/quality ratio in target markets compared to competitors' products.	-.02	**.66**
…provide sustainable competitive advantage for our organization.	-.08	**.67**
…solve very important problems of customers.	.21	**.71**
…achieve very high customer satisfaction.	.14	**.63**
Strategic renewal		
…help our organization to get new market areas.	**.72**	.10
…open new (future) product development opportunities.	**.84**	.05
…create new market know-how that can be utilized in the future.	**.74**	.11
…create new technological know-how that can be utilized in the future.	**.73**	.09

Principal component analysis with Varimax rotation

N = 133, MSA = .68, Total variance explained = 52%

4.4.2 Independent variables

This study includes seven management control variables (independent variables): input control, front end process formalization, outcome-based rewarding, strategic vision, informal communication, participative planning, and intrinsic task motivation.

Input control

Input control was operationalized by measuring two often discussed control mechanisms in the NPD context. The first two items concern management considerations of the persons who are selected for running the front end project and participating in the project as group members. Following the discussion of importance of group member selection and especially group leader selection[591] two new items were created to measure the extent to which management put emphasis on this selection process. The rest of the items regarded the definition of the forthcoming task to the front end group. Two new measurement items were created to measure the extent to which management defined the task and strategic goals for front end work.

[591] McGrath 1996, Nonaka 1988, Smith and Reinertsen 1998

The task definition item is based on the discussion of the importance of task assignments or even written contract books between the management and development group[592]. The other measurement item concerning the strategic goal-setting was based on the discussion of the importance of establishing strategic direction for NPD teams[593] and was modified from the items used by Bonner et al[594]. Factor loadings of this measurement construct are presented in Table 10. Cronbach's inter-item coefficient alpha for the input control is .79.

Front end process formalization

The front end process formalization measurement construct was created based on the extensive literature review of different process control mechanisms used in the NPD and front end context. The first item concerned the use of a reporting system informing the management about the progress of the front end project. This kind of status reporting has been regarded as an important diagnostic control tool in the literature[595]. The second measurement item measured the extent to which the front end project was executed in accordance with the defined process model. The item was derived from articles with intense discussion emphasizing the specification of the overall structure and procedures in the NPD context[596]. The third item reviewed the existence of specific evaluation gates during the front end. These review points enable the management to consider the progress of the project and make decisions about appropriate direction as well as continuing the project[597]. Finally, the fourth item measured the direct supervision over the procedures used by the front end group. This measurement item was adopted from Ramaswami but modified to the context of this study[598].

[592] Bonner 2002, Davila 2000, Ulrich and Eppinger 2003, Wheelwright and Clark 1992, Smith and Reinertsen 1998
[593] Imai et al. 1985, Bonner et al. 2002, Cooper 1998
[594] Bonner et al. 2002
[595] Simons 1995, Cleland and King 1975
[596] Hertenstein and Platt 2000, Bonner et al. 2002, Ulrich and Eppinger 2003, Tatikonda and Rosenthal 2000
[597] Davila 2000, Cleland and King 1975, Hertenstein and Platt 2000, Tatikonda and Rosenthal 2000
[598] Ramaswami 1996

Table 10. Measurement items and factor loadings for independent variables.

	Factors						
Measurement items	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Input control							
To what extent did management define the task for the development group?	.00	**.74**	.18	.08	-.05	.05	.30
To what extent did management define the strategic objectives for the front end work?	.15	**.60**	.30	.16	.09	.05	.12
To what extent did management consider who would be the appropriate person for managing the front end?	.14	**.83**	.07	-.15	.16	-.01	-.01
To what extent did management consider who would be the appropriate persons as front end group members?	.16	**.81**	.04	.10	.05	.03	-.01
Front end process formalization							
To what extent was a reporting system targeted towards management used?	.07	.18	**.74**	-.00	.15	.07	-.05
To what extent was the front end project executed according to the defined process model?	.07	.04	**.55**	-.12	-.18	.03	.48
To what extent did the front end project include decision points/gates where the project was evaluated from a strategic point of view?	.06	-.00	**.77**	.15	.19	.08	-.01
To what extent did management supervise that the front end group followed the defined procedures?	.11	.27	**.73**	.02	.05	.04	-.03
Outcome-based rewarding							
To what extent was the compensation of front end group members based on the objective evaluation of the achievement of defined goals?	.02	.16	.20	.16	**.82**	-.00	-.06
To what extent was the compensation of front end group members monetary compensation based on the achievement of defined objectives?	.05	.00	.19	.05	**.84**	-.08	.10
To what extent was the compensation of front end group members personal compensation based on individual accomplishment?	.02	.07	-.06	.05	**.70**	.23	-.10
Strategic vision							
The strategic vision guided the decision making of the front end group.	.09	.15	-.09	.16	-.00	.20	**.80**
Informal communication							
To what extent did the front end group informally communicate (e.g. hallway chats) with management?	**.86**	.18	.10	.09	.06	.08	.14
To what extent did the front end group informally exchange information (e.g. e-mail) with management?	**.91**	.11	.12	-.01	.05	.11	.01
To what extent did the front end group have informal meetings with management during the front end?	**.92**	.11	.05	.04	-.01	.09	-.02
Participative planning							
To what extent did the front end group have responsibility for defining strategic objectives for the front end project within the limits of the organization's strategy?	.05	.03	.10	.02	-.00	**.84**	.23
To what extent did the front end group participate in defining strategic objectives for the front end project?	.19	-.06	.10	.04	.12	**.80**	.28
To what extent did the front end group participate in defining formal control mechanisms for the front end project?	.07	.13	.02	.17	.05	**.70**	-.31
Intrinsic task motivation							
Members of the front end group took full responsibility for goal achievement set for the front end project.	.04	.02	.07	**.77**	.02	.04	.06
Members of the front end group did more than their share (exceeded expectations).	.09	.11	.06	**.82**	.05	.08	-.13
Members of the front end group were proud of the results achieved in the front end project.	-.03	-.01	-.03	**.79**	.18	.07	.19

Principal component analysis with Varimax rotation

N = 133, MSA = .69, Total variance explained = 71%

The front end process formalization measurement construct has high factor loadings except item number two (loading .55), which also considerably loads to factor seven (strategic vision), as can be seen from Table 10. However, this measurement item was retained in the final factor solution because of its expected high essentiality in the front end process formalization measurement construct i.e. as a mechanism of front end process formalization in practice. Cronbach's inter-item coefficient alpha for this construct is .79.

Outcome-based rewarding

Outcome-based rewarding was operationalized with measurement items focusing on rewarding structures used in the front end project. The main idea of rewarding from the control point of view is to tie goal achievement to compensation of group members, thus ensuring employees' motivation in contributing to organizational objectives[599]. Three measurement items were used. The first two items are derived from Bonner et al., who applied separate measures for rewarding through promotion and recognition and by financial means in the NPD context[600]. The first item of the outcome-based rewarding variable concerns financial rewarding and the second item other types of rewarding. While these first two items focus on collective rewarding on a group level, the third item was created focusing on rewarding based on individual accomplishment. Cronbach's inter-item coefficient alpha for the outcome-based rewarding variable is .76. Factor loadings of these items are again presented in Table 10.

Strategic vision

Strategic vision was operationalized with a single measurement item dealing with the influence of strategic vision on the decision-making of the front end group. The theoretical argument for this variable is derived from McGrath, who discusses compelling strategic vision giving direction for product development activities[601]. Strategic vision is connected to a broader context of belief systems providing an overall direction for the organization[602]. Belief systems are mainly used to inspire and guide organizational discovery and search activities[603]. The item was measured with a five-point Likert scale (1 = strongly disagree…5 = strongly agree).

Informal communication

Informal communication has an important role in controlling front end activities both as an independent activity and as complementing other types of control. Three measurement items were created based on the findings in the literature analysis which emphasize advantages such as flexibility and spontaneity of informal communication[604]. The first item measured the extent to which there was informal

[599] Chester 1995, Artto et al. 2004
[600] Bonner et al. 2002
[601] McGrath 1996
[602] Simons 1995
[603] Marginson 2002, Simons 1995
[604] Davila 2000, Merchant 1985, Anthony 1988, Cleland and King 1975

communication, the second the extent to which there was informal information exchange, and the third the extent to which there were informal meetings between the front end group and the management. Factor loadings of these items are presented in Table 10. Cronbach's inter-item coefficient alpha for this measurement construct is very high (.91).

Participative planning

The participative planning variable was operationalized in terms of the influence that the front end group members had on defining the forthcoming task and its strategic objectives. Three measurement items were used. The first two items were derived and modified from Bonner et al[605]. The first item measured the extent to which the responsibility of defining strategic objectives was transferred to the group within the limits of overall strategy. The second item measured the level of participation in defining the strategic objectives. The third item measured the extent to which the front end group had a role in defining formal control mechanisms for the project. This measurement item was developed based on the theoretical discussion by Ramaswami[606]. Factor loadings of these items are again presented in Table 10. Cronbach's inter-item coefficient alpha for participative planning is .73.

Intrinsic task motivation

Self-control means that the responsibility of controlling organizational activities is transferred from the external party, typically from management, to the employees carrying out the actual work activities. Because of the long cause-effect path between management first instituting activities that foster self-control and finally the activities manifesting self-control behavior, it was considered appropriate to measure self-control through its manifestations, i.e. the intrinsic task motivation of front end group members. If the characteristics of self-control are present it means that management can rely on self-control behavior, which further affects the final outcome. Following the ideas of Ramaswami, Kirsch, and Lawler and Hall, intrinsic motivation is measured in terms of the degree to which employees assume responsibility for their job activities and are intrinsically motivated[607]. The first two items measuring intrinsic task motivation were derived from Ramaswami and slightly modified to the context of

[605] Bonner et al. 2002
[606] Ramaswami 1996
[607] Ramaswami 1996, Kirsch 1996, Lawler and Hall 1970

this study.[608] The third item was adopted from Kirsch, and Lawler and Hall with some modifications. The items were measured with a five-point Likert scale (1 = strongly disagree…5 = strongly agree). Factor loadings of this measurement construct are presented in Table 10. Cronbach's inter-item coefficient alpha for the intrinsic task motivation is .74.

In general, the exploratory factor analysis supported the anticipated construct structure of independent variables well. Bartlett's statistic is significant and MSA is .69 for the created factor solution. The factor solution explains 71% of total variance.

4.4.3 Control variables

Several control variables were included in the regression model to take into account the potential effects of the firm, industry, and the front end project itself in the final results. Control variables for firm-level effects included the size and R&D intensity of the company. Industry-level effects were considered using the industry sector as a dummy variable including three categories: piece goods industry, process industry, and other industry. Control variables for front end project level effects included the original objectives set for the project, definition of the front end process, and the uncertainty included in the project.

Firm size

Several studies have shown that the size of the firm can affect the final outcome of the process as well as how the activities are generally organized (controlled) in the company[609]. Larger companies, for example, rely less on personal control and more on control through bureaucratic structures (rules and procedures)[610]. Murphy and Kumar have found that smaller firms are more successful (meet or exceed market projections) than large firms because the products are typically designed for the more specific needs of a small target group or built directly for a customer under a defined contract[611]. Turnover (in 2004) was used as a variable controlling the size effect in this study. Because of its strong negative skewness toward small sales figures, a logarithmic transformation of turnover was used.

[608] Ramaswami 1996
[609] Donaldson 2001, Murphy and Kumar 1996, Ouchi 1977
[610] Donaldson 2001, Jaworski 1988
[611] Murphy and Kumar 1996

R&D intensity

Murphy and Kumar found that the intensity of the firm's R&D efforts predicted activities across the front end, for example R&D-intense firms stressed the importance of creativity and the utilization of internal employees in the idea generation process[612]. The size of the firm is naturally related to the number of different R&D projects undertaken[613]. Thus instead of the number of different R&D projects, logarithmic transformation of the percentage of turnover invested in R&D was used to control R&D intensity.

Industry sector

Industry sector was measured by requesting that respondents indicate the industry sector in which the company is operating (open-ended question). The classification of three dummy variables was done by the author post-hoc. From the management control point of view, it was considered appropriate to have two broader categories, piece goods industry and the process-based production industry, with specific characteristics that may influence the final performance of front end projects. Industries such IT/ICT technology and medical/biomedical were classified under the label "other industry".

Objectives of front end project

The nature of defined objectives may have an effect on the final performance of the front end project[614]. The objectives of the development project were controlled by using two categories (a dummy variable). Respondents were requested to choose (which one of the statements describes the project objectives better) whether the objective of the project was to improve long-term profitability or short-term cash flows. The objectives of the development project are closely related to the other project-level control variable 'uncertainty'.

[612] Ibid.
[613] Ibid.
[614] Griffin and Page 1996

Definition of front end process

The existence to which the front end process was defined was used as a control variable. Respondents were requested to choose from four categories: not defined at all, defined superficially, defined in some detail, and defined in great detail. Definition of the front end process may indicate its perceived importance and a general maturity level of front end execution.

Uncertainty included in the development project

Uncertainty was used both as a control variable and as a moderating variable in multiple linear regression analyses. A wide body of knowledge exists to measure uncertainty in different business contexts. The measurement items were modified to fit the context of this study from Danneels and Kleinschmidt[615], Garcia and Calantone[616], and Danneels[617] that all measured uncertainty in the product innovation context. The items were measured with a five-point Likert scale (1 = strongly disagree…5 = strongly agree).

There are two main issues defining uncertainty in the product innovation context: applied technology and the target market[618]. The more new technology the product includes or the more unfamiliar the target market is, the more uncertainty the development task includes. Thus the uncertainty measurement covered both market and technology dimensions. Garcia and Calantone emphasized that product innovativeness (the uncertainty the product includes) must be evaluated from two different perspectives: the macro-level industry perspective and the micro-level company perspective[619]. The first two items reflects this notion both in market uncertainty and technology uncertainty variables. Considering this distinction, these items were modified to fit the context of this study from Danneels and Kleinschmidt, who used these measurement items in the market familiarity and technological familiarity measurement constructs[620]. The third and fourth items in both constructs relate to the discussion of whether the new products can rely on the firm's existing technological and marketing competencies or not. This is an important measure of

[615] Danneels and Kleinschmidt 2001
[616] Garcia and Calantone 2002
[617] Danneels 2002
[618] Tidd et al. 2001, Danneels and Kleinschmidt 2001, Lynn and Akgun 1998
[619] Garcia and Calantone 2002
[620] Danneels and Kleinschmidt 2001

uncertainty in this study since products with a closer fit with the existing competences of the firm tend to be more successful on average[621]. The third and fourth items in the market uncertainty construct and the third item in the technology uncertainty construct were modified from Danneels and Kleinschmidt[622]. The fourth item in the technology uncertainty construct was created and found to be functioning adequately, based on the discussion of Danneels and Kleinschmidt[623].

Table 11 illustrates factor loadings for these two measurement constructs. Two different factors with a clear factor solution and high loadings were found as expected. Bartlett's statistic is significant, MSA is .69, and the factor solution explains 63% of total variance. Cronbach's inter-item coefficient alpha for the market uncertainty construct is .76 and the technology uncertainty construct .84.

Table 11. Measurement items and factor loadings for market uncertainty and technology uncertainty constructs.

Measurement items	Factor 1	Factor 2
Market uncertainty		
The planned target markets for the product concept were new to our organization.	,15	**,84**
The planned target markets for the product concept were also new to other companies in the industry of our organization.	,11	**,75**
Our organization's existing market research capabilities were not adequate for the gathering of market information needed for the product concept.	,09	**,72**
The market research/gathering of market information was done by using new methods that were not previously used in our organization.	,17	**,68**
Technology uncertainty		
The applied technology in the product concept was new to our organization.	**,90**	,06
The applied technology in the product concept was also new to other companies in the industry of our organization.	**,84**	,09
Our organization's existing R&D capabilities were not adequate for developing the product concept.	**,65**	,23
Technology development and technology verification of the product concept was done using new methods that were not previously used in our organization.	**,82**	,19

Principal component analysis with Varimax rotation
N = 133, MSA = .69, Total variance explained = 63%

[621] Danneels 2002
[622] Danneels and Kleinschmidt 2001
[623] Ibid.

4.5 Reliability and validity analysis

Measurement is at the core of quantitative survey research. Measurement is defined here as according to Bohrnstedt: "*Measurement is the assignment of numbers to observed phenomena according to certain rules*"[624]. There are two types of error, one of them dealing with measurement, that arise in survey research. First, there is random error caused mainly by sampling techniques that occurs in all kinds of research. Statistical programs consider the probability that the random error causes the particular result. The other type of error is measurement error, which indicates how well a particular measurement instrument works in a target population.[625] Measurement error is the difference between the observed and unobserved, true variable[626]. The existence of measurement error is a key concern since random error is something that cannot be influenced. There are two ways of assessing the appropriateness of the measurement instrument used. The first is validity, i.e. whether the measurement instrument is measuring what it is intended to measure and the second is reliability i.e. the degree to which re-measurement with the same measurement instrument would lead to the same results.[627] The following chapters investigate the reliability and validity of the research from various viewpoints.

4.5.1 Reliability

Reliability reflects the precision of the survey instrument, i.e. how reproducible the data of the survey instrument is[628]. In mathematical terms, reliability is the ratio of true score variance (i.e. non-random variance) to the observed variance[629]. To make a study more reliable, multi-item measurement constructs are used. Internal consistency reliability can be calculated for the group of measurement items that measure different aspects of the same phenomenon. Internal consistency can be expressed in the form of Cronbach's coefficient alpha, which measures reliability among a group of items combined to form a single scale. Cronbach's alpha reflects how well different items complement each other in measuring different aspects of the same concept.[630] The value of Cronbach's alpha is determined by the average correlation of each item with

[624] Bohrnstedt 1983 p. 70
[625] Litwin 1985
[626] Bohrnstedt 1983
[627] Bohrnstedt 1983
[628] Litwin 1985
[629] Bohrnstedt 1983
[630] Litwin 1985

every other item in the group and the number of items used in the measurement construct[631]. Cronbach's alpha level .70 is the generally accepted threshold value for good reliability[632]. However, lower reliabilities such as .60 may be appropriate in some research studies[633]. Low reliability is problematic since it tends to attenuate correlations between investigated measurement constructs, and it leads to underestimating the relationships between constructs[634].

Table 12 summarizes the results of the factor analysis including Cronbach's alpha values for each measurement construct used in this study. Ten multi-item measurement constructs including 8 independent variables and 2 dependent variables are used in this study. In addition, one independent variable is measured by using only a single item. All the Cronbach's alphas are above the general threshold value .70 expect one variable (product concept superiority) which has the alpha value .69. The highest alpha values were reported in the informal communication (.91) and technology uncertainty (.84) measurement constructs.

Table 12. Internal consistency coefficients of measurement constructs.

Measurement construct	Number of items	Cronbach's α	Number of cases
Input control	4	.79	132
Front-end process formalization	4	.79	126
Outcome-based rewarding	3	.76	119
Strategic vision	1		
Informal communication	3	.91	131
Participative planning	3	.73	127
Intrinsic task motivation	3	.74	130
Market uncertainty	4	.76	128
Technology uncertainty	4	.84	130
Product concept superiority	5	.69	129
Strategic renewal	4	.76	131

[631] Nunnally 1978, Dooley 1980
[632] Litwin 1985, Nunnally 1978
[633] Hair et al. 1998, Dooley 1980
[634] Nunnally 1978

Clarity of the survey and understandability of questions were confirmed in several ways. This was done to increase the reliability of the study[635]. Existing items and variables were used whenever possible. The questionnaire was also thoroughly tested with practitioners and academics as discussed earlier. These tests led to minor modifications in the questionnaire to make it more understandable. The final feedback indicated that both instructions and questions were clear and that respondents knew how to answer the questionnaire. The clarity and understandability of the questionnaire is indicated by the small amount of missing data. The used measures pointed to only 1.56% of missing data. The influence of this missing data was found to be insignificant. The items of independent variables concerned the intensity of the use of certain control mechanisms, which was considered to give a more concrete evaluation point compared to simply asking for an opinion on a certain statement. In addition, the exact objective figures were used in control variables whenever possible.

This survey study relies on the judgment of a single respondent, which increases the possibility of lower reliability. The bias is less significant the more competent the key informants are[636]. Special attention was put on informant selection. The questionnaire was sent to the appropriate director-level person or R&D-responsible person in the selected companies. These persons were considered to have the best possible knowledge of the investigated phenomenon. If the person was not in the rightly defined position in the organization to respond to the survey, that person was requested to forward the questionnaire onto the correct person. The study relies on perception-based measures of informants both in dependent and independent variables when objective measures were not available. This is not necessarily, however, a serious threat for reliability. For example, Dess and Robinson have found subjective perception and objective measures to strongly correlate in measuring organizational performance in terms of return on assets and growth in sales[637]. Further, they emphasize that subjective measures are useful especially in attempting to operationalize broader, non-economic dimensions of organizational performance[638].

[635] Nunnally 1978
[636] Ernst and Teichert 1998
[637] Dess and Robinsson 1984
[638] Ibid.

The literature analysis revealed that tested measurement constructs available for studying management control in the front end of innovation are limited. Lack of verified constructs resulted in the need to create new items and measurements constructs. In addition, this study relies on a single management representative's own report of both independent and dependent variables in each company. This self-reporting may cause common method variance i.e. cause additional correlation among variables[639]. Several preparations and remedies were used to remove common method variance. First a priori verified measurement items were used whenever possible. Different items belonging to the same construct were asked in different places in the questionnaire form in order to avoid 'consistency motif', i.e. a tendency to maintain a consistent line in a series of answers[640]. As a post hoc remedy, some scale trimming was made, i.e. some measures causing overlapping constructs were eliminated[641].

Herman's one-factor test was also used to analyze common method variance. All the independent variables, and dependent variables separately, were entered in the factor analysis simultaneously. This resulted in 7 independent factors and 2 dependent factors as expected. In addition, the first general factor accounted only for 23.45% of the covariance of independent variables and 32.52% of the covariance of dependent variables respectively. This gives some indication that common method variance is not a serious problem in this study.[642] However, an upward shift in the distribution of responses give reason to doubt that some 'social desirability problems' may exist, i.e. respondent may have answered questions in a manner that present a respondent in a favorable light[643]. This was despite the fact that full confidentiality and anonymity, if desired, were promised to respondents.

4.5.2 Validity

A reliability assessment is an essential but not sufficient activity for determining the psychometric appropriateness of the measurement instrument. Thus the reliability assessment should be complemented with a validity assessment. Validity refers to

[639] Avolio et al. 1991, Podsakoff and Organ 1986
[640] Podsakoff and Organ 1986
[641] Ibid.
[642] Podsakoff and Organ 1986
[643] Ibid.

"*the degree to which an instrument measures the construct under investigation*" [644]. There are four types of validity typically considered and discussed in the following: face validity, content validity, criterion validity, and construct validity.

Face validity refers to the casual assessment of item appropriateness in the measurement instrument[645]. In other words, face validity is high if the measurement instrument is line with the common understanding of the investigated phenomena. Content validity refers to the appropriateness of the measurement instrument, usually judged by experts in the investigated phenomenon[646]. The measurement instrument should cover all the relevant items in the investigated domain. This study followed the ideas of Bohrnsted to increase content validity and face validity[647]. First, extensive literature analysis was conducted to find all the relevant aspects of management control and front end performance. Further, the literature analysis covered existing research to find an appropriate means of measuring the different features of the investigated phenomenon. The results of the literature analysis were complemented by my own insight and experiences from my former qualitative studies[648]. Intensive discussions about the appropriateness of different measurement items and variables were conducted with research colleagues while building a measurement instrument. The questionnaire was tested with colleagues to find possible flaws in the coverage of used items, understandability and practical usability. In addition, existing validated measurement items were used and applied whenever possible. Second, multi-item measurement constructs were used to measure different features of management control and front end performance. This ensured adequate coverage of the relevant items in the variables. Third, the developed questionnaire was formally pre-tested with several academics and practitioners to increase content validity of the measurement instrument. The open-ended question in the questionnaire, which asked the respondent to state other relevant control mechanisms used that were not covered in the survey, gives some indication of the content validity. Only 12 (9.0%) respondents stated that there were some other relevant control mechanisms used in the front end project not mentioned in the questionnaire. It is important to note, however,

[644] Bohrnstedt 1983 p. 97
[645] Litwin 1985
[646] Ibid.
[647] Bohrnstedt 1983
[648] Poskela 2007, Poskela 2006, Poskela 2005

that some control mechanisms that were studied in the survey were consciously excluded in the study in order to maintain a manageable research design. Thus this study does not cover e.g. boundary control, peer control, management intervention, use of screening criteria in different phases of the front end or the use of competition as a control mechanism. Seven different control mechanisms that are intensively used by practitioners and that represent different alternative control modes were selected for this study.

Criterion validity can be defined as the correlation between a used variable and a criterion variable in a domain of interest[649]. This criterion variable should be external to current empirical investigation and previously validated. In survey research, the criterion validity is of limited use because researchers seldom have previously validated criterion variables in a similar context[650]. There are two components of criterion validity: concurrent validity and predictive validity. The use of concurrent validity requires that the used survey instrument can be evaluated against some other measurement instrument that is generally accepted as a good standard to measure the investigated phenomenon.[651] To ensure concurrent validity, the existing validated measurement items were used whenever possible, e.g. in market and technology uncertainty measurement constructs. However, the lack of previously validated variables makes it impossible to assess concurrent validity in detail. Predictive validity is the ability of the measurement instrument to predict the investigated outcome[652]. The regression models explained 15–27% (adjusted R^2) of the variance of dependent variables. Predictive validity is demonstrated in detail in the results chapter (Chapter 5) while discussing the results of the hypotheses tests.

Construct validity refers to the extent to which the measurement item reflects the theoretical concept it is supposed to measure[653]. Construct validity is a measure of meaningfulness of the measurement instrument and refers to the ability of the instrument to perform in different research settings and target populations[654]. The assessment of construct validity is important in order to understand the influence of

[649] Bohrnstedt 1983
[650] Ibid.
[651] Litwin 1985
[652] Ibid.
[653] Dooley 1980
[654] Litwin 1985

possible random error and measurement error on final results, i.e. the possibility of accepting or rejecting a hypothesis because of excessive error[655]. Combining several measurement items provides greater construct validity and scientific generalizability in the investigated domain compared to using only a single item[656].

Construct validity comprises two components: convergent validity and discriminant (divergent) validity[657]. Convergent validity means the degree to which multiple attempts to measure the same concept are in agreement. Different items measuring the same issue should covary highly to be valid measures of the investigated phenomenon. Discriminant validity, in turn, means the degree to which measurement items of different concepts are distinct. The valid measures should not correlate too highly in the situation when two or more concepts are unique.[658] Factor analysis is recommended to be used to assess construct validity and is also applied in this study[659].

Factor analysis can be used to identify different constructs (factors) among the set of measurement items and to asses the undimensionality of constructs. To assess convergent validity, factor analysis was carried out for each measurement construct. All the factor loadings exceeded .45, which is regarded as a statistically significant level with this sample size[660]. Further, convergent validity was assessed by detecting inter-item correlation inside the factors as suggested by Hair et al[661]. The inter-item correlations generally exceeded the threshold value of .30, indicating a good convergent validity with a few exceptions (Table 13).

In the front end process formalization measurement construct there was a low correlation between items 1 and 2 (.25) and between items 2 and 4 (.29). This is caused by a low factor loading of item 2 (.55), but as explained earlier, it was retained in the final factor solution for theoretical reasons. In the market uncertainty measurement construct there was a low correlation between items 2 and 3 (.29), and

[655] Bagozzi et al. 1991
[656] Nunnally 1978
[657] Campbell and Fiske 1959, Bagozzi et al. 1991, Litwin 1985
[658] Bagozzi et al. 1991
[659] Bagozzi et al. 1991, Dooley 1980
[660] See the discussion in Chapter 4.3.1
[661] Hair et al. 1998

between items 2 and 4 (.28). In the dependent variable product concept superiority there was a low correlation between items 1 and 5 (.23), between items 2 and 5 (.17), between items 3 and 4 (.17), and between items 3 and 5 (.28).

Table 13. Within-construct correlations and cross-construct correlations.

Measurement construct	Range of within-construct correlations	Number of cross-construct correlations that exceed within-construct correlations
Input control	.37 - .58	0/116
Front-end process formalization	.25 - .66	0/116
Outcome-based rewarding	.37 - .64	9/116
Strategic vision	-	-
Informal communication	.74 - .75	0/87
Participative planning	.35 - .69	0/87
Intrinsic task motivation	.42 - .56	0/87
Market uncertainty	.28 - .71	2/116
Technology uncertainty	.36 - .77	0/116

In addition, convergent validity was dealt with while building the measurement instrument by using earlier validated variables as much as possible and by strongly relying on theoretical analyses while constructing new measurement constructs.

Several procedures were carried out to assess the discriminant validity of the measurement instrument. Again, discriminant validity was ensured by using earlier validated constructs as much as possible and by strongly relying on theoretical analyses while constructing new variables. Factor analysis was used to analyze whether the expected factors were distinct from each other. All the items with one exception loaded .30 or lower in other than the primary factor in the analysis. Item 2 in the front end process formalization variable loaded also in the construct of strategic vision, the loading being .48, but the item was retained in the model from theoretical reasons. This indicates good discriminant validity in general in this study. Further, a small number of cross-construct correlations exceeding within-construct correlations is a sign of good discriminant validity[662].

Table 13 shows that only the variables outcome-based rewarding and market uncertainty have cross-construct correlations that exceed the within-construct

[662] Campbell and Fiske 1959

correlations, indicating good discriminant validity. In addition, Herman's one-factor test was used to analyze the existence of common method variance and was found not to be a problem for the validity of this research.

Chapter 4.2.4 discussed non-response bias and whether the sample was representative of the population. Table 8 showed that the differences between early and late respondents in terms of turnover, percentage of turnover invested in R&D, and number of employees were close to the statistical significance. Because of this, the figures between these two groups were taken into closer investigation. The investigation revealed that the reason for the almost statistically significant differences was due to a few outliers that existed in the data. The two biggest companies in terms of turnover were among the early respondents. These companies were big international corporations with a turnover considerably higher than the other companies. The two highest R&D investors of the sample (relative to their turnover) were among the late respondents. These companies (a biotechnology company and a company conducting only R&D work in Finland) invested considerably more than their turnover in R&D. In terms of number of employees, the three biggest companies were among the early respondents. Again these companies were large international corporations with considerably more employees than the other companies in the sample. Omitting these companies from the analysis led to results that were not even close to statistical significance. This same phenomenon can also be seen from high standard deviations in all three figures caused by a few outliers. Thus it can be argued that the sample was representative of the population and the results can, from this perspective, be generalized for the whole population. The external validity, i.e. generalizability of the results, is discussed in detail in the limitation chapter (Chapter 7.3).

5 RESULTS

***"When novelty and unfamiliarity in both market situation and technical information become the accepted order of things, a fundamentally different kind of management system becomes appropriate from that which applies to a relatively stable commercial and technical environment."* – Burns and Stalker 1961**

The results chapter starts by giving background information on the investigated companies and the front end projects to provide the reader with a better contextual understanding of the research objects. This is followed by a discussion of the results of the hypotheses tests.

5.1 Descriptive analysis

Of the descriptive information reported below, the size and R&D intensity of the company, the industry sector, the original objectives set for the project, the definition of the front end process, and the uncertainty included in the project were used as control variables in regression analyses.

5.1.1 Size

The size of the sample companies was measured both in terms of revenue and number of employees. Table 14 shows that 40.6% of companies were medium-sized (number of employees 50–249) and 57.9% large (number of employees over 250). On average, the companies had 3608 employees, the highest figure being 100 000. Despite the sampling criterion of 'medium-sized companies' (more than 50 employees) in this study, there were two companies that should be classified as 'small companies' (with 35 and 40 employees). These companies were retained in the final sample because they had a relatively high investment in R&D and therefore the importance of management control in the front end of innovation was emphasized in these organizations.

Table 15 presents the distribution of revenue in the sample companies. The range of revenue is large from 0 to 31 billion euros. The highest frequency of companies falls into the category of 10 to 49.99 million euros (40 companies). Table 15 shows that the sample included 17 very large companies with revenue of over 1 billion euros. It is

important to note that the variability in both size measures, the number of employees and revenue, is high, as evident from the standard deviation figures. In addition, both distributions are skewed toward small figures, as can be interpreted from the mean and median figures as well as classification frequencies.

Table 14. Number of employees in sample companies in 2004.

Number of employees in 2004	Number of companies	Percentage
0 - 49	2	1.5%
50 - 249	54	40.6%
250 - 999	35	26.3%
1000 - 9999	32	24.1%
Over 10 000	10	7.5%
Total	133	100.0%

N	Mean	Median	Std.Dev.	Min	Max
133	3607.50	350	11321.11	35	100000

Table 15. Revenue of sample companies in 2004.

Revenue in 2004 (Million €)	Number of companies	Percentage of non-missing
0 - 9.99	13	9.8%
10 - 49.99	40	30.3%
50 - 149.99	29	22.0%
150 - 999.99	33	25.0%
Over 1000	17	12.9%
Total	132	100.0%

N	Mean	Median	Std.Dev.	Min	Max
132	988.19	92.00	3688.27	0	31000

5.1.2 R&D intensity

Table 16 shows that 31.4% of companies can be classified as being 'low R&D intensive' (only 0–1.99% of turnover invested in R&D). Approximately a quarter of companies (25.7%) invested more than 5% of their turnover to R&D. R&D intensity illustrates the relative emphasis of innovation activities in comparison to other organizational activities in the companies. The more R&D intensive the companies are, the more important management control can be expected to be in these companies

in the front end of innovation. Three companies invested more than their yearly turnover in R&D. These included a biotechnology company and two research units (independent companies) that develop product concepts only to be sold to industrial customers. The highest figure in R&D investments was 200% and the mean value 7.38%. Again, values have high variability and are skewed toward small figures.

Table 16. Percentage of revenue invested in R&D in sample companies in 2004.

Percentage of revenue invested in R&D in 2004	Number of companies	Percentage of non-missing
0 - 1.99	38	31.4%
2 - 4.99	52	43.0%
5 - 9.99	14	11.6%
10 - 99.99	14	11.6%
Over 100	3	2.5%
Total	121	100.0%

N	Mean	Median	Std.Dev.	Min	Max
121	7.38	2.70	22.25	0	200

The above figures pertain to the companies as a whole. At the beginning of the questionnaire respondents were asked to choose whether to answer the questions from the viewpoint of a single business unit or the whole company. Furthermore, respondents were advised to answer in terms of business unit if they were working in a unit which had its own strategy and profit responsibility. The purpose of this was to clarify the background of the organization, especially in large companies which may include business units of a very different nature, e.g. in terms of strategy or structure. Responses were spread almost equally, with 53.2% of respondents answering from the whole company's point of view and 46.8% from a single business unit's point of view. In the following chapters, the term company refers to either the business unit or the whole company, depending on the choice that the respondent made.

5.1.3 Industry

The companies are classified under three broad categories in Table 17: piece good industry, process-based production industry, and other industries. The majority of companies came from the piece good industry (50.4%). This category included industries such as the metal industry (metal processing), the electrical and electro-

technical industry, and the machine shop industry. One third of the companies (32.3%) operated within the process-based production industry. Industries such as metal production, construction material production, grocery production, pulp, paper and mechanical wood production, and chemical production fall into this category. The third broad category, other industries (17.3% of companies), included e.g. information and communication technology companies, and medical and biomedical companies. Industry sector of the sample companies was asked with an open-ended question and the classification is based on the author's own analysis post-hoc.

Table 17. Industry of sample companies.

Industry	Number of companies	Percentage
Piece good industry	**67**	**50.4%**
Metal industry	*7*	5.3%
Construction industry	*1*	0.8%
Electrical and electro-technical industry	*17*	12.8%
Machine shop industry	*42*	31.6%
Process-based production industry	**43**	**32.3%**
Metal production	*6*	4.5%
Construction material industry	*5*	3.8%
Grocery industry	*6*	4.5%
Forest industry	*11*	8.3%
Chemical industry	*12*	9.0%
Others	*3*	2.3%
Other industries	**23**	**17.3%**
Information and communication technology industry	*9*	6.8%
Medical and biomedical industry	*3*	2.3%
Others	*11*	8.3%
Total	**133**	**100.0%**

5.1.4 Business markets and business strategy

The majority of the sample companies (67.4%) operated in business-to-business (B2B) markets as illustrated in Table 18. Only 15.5% of the companies operated in business-to-consumer markets and the rest of the companies (17.1%) stated operations in both business environments. Thus the results reflect more the operations of companies in B2B markets.

Table 18. Business market of sample companies.

Business markets	Number of companies	Percentage of non-missing
Business-to-consumer (B2C)	20	15.5%
Business-to-business (B2B)	87	67.4%
Combination of B2C and B2B	22	17.1%
Total	129	100.0%

Sample companies followed a combination of cost leadership and differentiation strategies (43.1% of companies), as illustrated in Table 19. This may reflect the fact that the majority of the companies operated in B2B markets and probably pursued a focus or niche strategy[663] which may combine characteristics of cost leadership and differentiation strategies. Cost leadership was the goal for 21 companies (16.2%) and differentiation for 50 companies (38.5%). Management control in the front end of innovation can be argued to play a more important role in companies following differentiation strategy because of the continuous need to develop new product innovations.

Table 19. Business strategy of sample companies.

Business strategy	Number of companies	Percentage of non-missing
Cost leadership (CL)	21	16.2%
Differentiation (D)	50	38.5%
Combination of CL and D	56	43.1%
Other	3	2.3%
Total	130	100.0%

5.1.5 Organizing the front end of innovation

Table 20 illustrates the general organization structure in the sample companies. Over half of the companies (50.4%) applied a matrix organization structure, 33.6% a line organization structure, and 13.0% project organization structure. Inside this general organization structure, 79 companies (59.4%) had a separate group of people whose responsibilities included the development of new product concepts.

[663] Porter 1980

Table 20. Organization structure of sample companies.

Organization structure	Number of companies	Percentage of non-missing
Line organization	44	33.6%
Matrix organization	66	50.4%
Project organization	17	13.0%
Other	4	3.1%
Total	131	100.0%

The majority of companies (88.5%) had defined some kind of front end process to help the management of front end activities, as shown in Table 21. The greatest percentage of companies (49.6%) had defined a rough model describing the steps of front end execution. Only seven companies (5.3%) had defined a very detailed process model. The figures indicate that the sample companies have had development interventions to create a systematic approach to front end execution. Only 11.5% of the sample companies had no defined process model for the front end. The sample companies, however, had no common, company-wide approach to controlling the front end of innovation. Almost two-thirds of the companies (60.3%) stated that the organization did not apply a common approach to management control.

Table 21. Level of detail of front end process model definition in sample companies.

Level of detail of front-end process model definition	Number of companies	Percentage of non-missing
Not defined at all	15	11.5%
Defined superficially	65	49.6%
Defined in some detail	44	33.1%
Defined in great detail	7	5.3%
Total	131	100.0%

Several product concepts were simultaneously under development in the sample companies (Table 22). Most of the companies (26.7%) had four to five individual development interventions simultaneously underway. The highest number of simultaneous front end projects was 100 and the mean figure 6.5.

Table 22. Average number of simultaneous front end projects in sample companies.

Number of simultaneous front-end projects on average	Number of companies	Percentage of non-missing
1	13	9.9%
2	29	22.1%
3	20	15.3%
4-5	35	26.7%
6-10	23	17.6%
Over 10	11	8.4%
Total	131	100.0%

N	Mean	Median	Std.Dev.	Min	Max
131	6.50	3.50	10.77	1	100

5.1.6 Example front end project

The respondents were asked to choose the last thoroughly executed front end project as an example and base their answers on that particular project. The majority of these projects (97.7%) were initiated to improve the long-term profitability of the company. Only 2.3% of companies stated that the main objective of the front end project was to improve short-term cash flows. This is quite understandable considering that the front end phase is typically thoroughly executed only in situations that aim at considerable changes in existing products or for totally new products. Minor product modification interventions are typically started by directly launching a NPD project. The sample companies seemed to be quite proactive in their development activities. The great majority (84.6%) of companies initiated the front end project to bring competitive advantage for the company. Only 15.4% of companies initiated the front end project as a response to an identified external market threat. The example front end projects lasted 16 months on average. The shortest project took only three months to execute, whereas the longest project took six years and two months.

5.1.7 Intensity of use of different management control mechanisms

The intensity of use of different control mechanisms is illustrated in Table 23, which shows the means and standard deviations of the used control mechanisms. Management trusted the influence of strategic vision and intrinsic task motivation the most (mean figures 4.06 and 3.82 respectively on a scale of 1–5). The intensity of use

of these control mechanisms was significantly different compared to the average use of control mechanisms (strategic vision: t (132) = 14.19, p = .00; intrinsic task motivation: t (132) = 10.59, p = .00). This indicates an emphasis on using softer control mechanisms. Informal communication (3.43), input control (3.26), and participative planning (3.10) were used with medium intensity. Front end process formalization (2.65) and outcome-based rewarding (2.01) were used with quite a low intensity in controlling front end projects. The intensity of use of these control mechanisms was significantly different to the average use of control mechanisms (front end process formalization: t (132) = -8.25, p = .00; outcome-based rewarding: t (125) = -14.67, p = .00).

Table 23. Intensity of use of different management control mechanisms.

Management control mechanism	Mean	Std.Dev.
Input control	3.26	.80
Front-end process formalization	2.65	.74
Outcome-based rewarding	2.01	.89
Strategic vision	4.06	.72
Informal communication	3.43	.89
Participative planning	3.10	.72
Intrinsic task motivation	3.82	.70

5.2 Correlations among variables

Correlation coefficients among variables used in regression models are displayed in Table 24[664]. There are some statistically significant correlations among variables. Input control positively correlates with the dependent variable strategic renewal, but not with product concept superiority. Input control also positively correlates with some other independent variables, namely front end process formalization, outcome-based rewarding, strategic vision, participative planning, and informal communication. In addition, input control is positively associated with two control variables, R&D intensity and definition of the front end process.

Front end process formalization positively correlates with the dependent variable product concept superiority, but not with strategic renewal. A strong positive

[664] Control variables "piece good industry" and "process based production industry" were based on post-hoc classification. Control variables "objectives of the development project" and "definition of front end process" were measured with a nominal scale.

correlation between these variables indicates that front end process formalization may actually be positively (contrary to the hypothesized relationship) related to product concept superiority. Front end process formalization also positively correlates with three other independent variables, namely outcome-based rewarding, participative planning, and informal communication. A positive correlation can also be found between product concept superiority and the control variables R&D intensity, the piece good industry and definition of the front end process.

Table 24. Correlations among variables.

Variable	Mean	Std.Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Product concept superiority	3.84	.54																
2. Strategic renewal	3.85	.76	.27**															
3. Input control	3.26	.80	.15	.21*														
4. Front-end process formalization	2.65	.74	.23**	.03	.41**													
5. Outcome-based rewarding	2.01	.89	.03	.10	.21*	.26**												
6. Strategic vision	4.06	.72	.22**	.09	.19*	.10	.00											
7. Informal communication	3.43	.89	.05	.07	.31**	.26**	.12	.15										
8. Participative planning	3.10	.72	.11	.13	.21*	.29**	.16	.40**	.25**									
9. Intrinsic task motivation	3.82	.70	.13	.20*	.13	.11	.25**	.20*	.11	.18*								
10. Market uncertainty	2.37	1.01	.12	.41**	.00	-.03	.17	.09	.18*	.16	.05							
11. Technology uncertainty	2.90	1.08	.12	.38**	.15	.04	.18*	.03	.10	.02	.05	.34**						
12. Size			-.26**	-.00	-.16	-.02	.04	.15	.04	.07	.00	-.10	.00					
13. R&D intensity			.29**	.06	.30**	.27**	.16	.08	.14	.05	-.09	.10	-.05	-.33**				
14. Piece good industry			.11	.12	.07	.22*	.07	-.15	.05	.04	-.02	-.11	.22*	-.12	-.12			
15. Process-based production industry			-.09	-.07	-.03	-.15	.03	.11	-.06	.16	.06	.00	-.07	.30**	-.40**	-.68**		
16. Objectives of the development project			-.05	-.03	.07	.10	.06	.02	.13	.31**	.21*	.03	-.05	.09	-.02	.16	.10	
17. Definition of front-end process			.05	-.05	.19*	.43**	.19*	.20*	.20*	.18*	.14	-.07	.05	.15	.10	.08	.00	.00

* p < .05; ** p < .01
two-tailed test

Table 24 illustrates that outcome-based rewarding positively correlates with intrinsic task motivation and two control variables, namely technology uncertainty and definition of the front end process. Strategic vision positively correlates with the dependent variable product concept superiority, but not with strategic renewal. In addition, strategic vision positively correlates with two other independent variables (intrinsic task motivation, and participative planning) and with the control variable definition of the front end process. The independent variable, informal communication, positively correlates with participative planning and the control variables market uncertainty and definition of the front end process. Table 24 further shows that participative planning positively correlates with intrinsic task motivation and two control variables (objectives of the development project and definition of the front end process).Intrinsic task motivation has a positive correlation with the

dependent variable strategic renewal, but not with product concept superiority. Intrinsic task motivation also positively correlates with the control variable objectives of the development project.

Market uncertainty positively correlates with the dependent variable strategic renewal and with the control variable technology uncertainty. Technology uncertainty also positively correlates with strategic renewal and with the other control variable, the piece good industry. Firm size negatively correlates with the dependent variable product concept superiority and with the other control variable R&D intensity. Firm size has a positive correlation with the process-based production industry. R&D intensity positively correlates with the dependent variable product concept superiority, and negatively with the control variable process-based production industry. Finally, the piece good industry negatively correlates with the process-based production industry.

Significant correlations between the independent variables and dependent variables are all positive and no negative correlations can be found in Table 24. This indicates that there are only positive associations between the management control variables and front end performance variables.

5.3 Regression analyses

Multiple linear regression analysis was used to test the hypotheses put forward in Chapter 3. The summated scales for independent and dependent variables were used after conducting the exploratory factor analysis for them. Altogether, 10 regression models were analyzed.

5.3.1 Regression analyses for product concept superiority

The results of testing hypotheses H1a–H7a, H8a and H8b, and H9a and H9 are given in Table 25. The first column shows the independent, control and moderated variables entered in the regression model. The next five columns show different regression models with standardized beta coefficients and their significance levels for each variable. For the hypothesized paths, the significance test is one-tailed. For the control variables, the significance test is two-tailed. All the independent variables were entered simultaneously in the regression models when testing predicted direct

relationships. Predicted moderated relationships were tested one at a time. Entering the base line model (only control variables) into the regression analysis gives the following results: $R^2 = .16$, adjusted $R^2 = .10$, $F = 2.84$, $p \leq .05$.

Table 25. Results of regression analyses for product concept superiority.

Variables entered	Model 1	Model 2	Model 3	Model 4	Model 5
Independent variables					
Input control	-.07	-.08	-.07	-.07	-.06
Front-end process formalization	.20**	.17**	.21**	.20**	.22**
Outcome-based rewarding	-.09	-.08	-.10	-.09	-.08
Strategic vision	.23***	.21***	.23***	.23***	.24***
Informal communication	-.04	-.09	-.04	-.04	-.04
Participative planning	-.01	.00	-.01	.01	-.03
Intrinsic task motivation	.14*	.14**	.14*	.14*	.12*
Control variables					
Market uncertainty	.11	.11	.12	.10	.09
Technology uncertainty	.06	.11	.06	.07	.06
Size	-.26**	-.24**	-.25**	-.25**	-.27**
R&D intensity	.24**	.28**	.23**	.23**	.23**
Piece good industry	.25*	.29**	.26**	.25*	.23*
Process-based production industry	.27**	.27**	.27*	.26*	.26*
Objectives of the development project	-.12	-.10	-.12	-.11	-.12
Definition of the front-end process	-.06	-.04	-.07	-.06	-.05
Moderated variables					
Front-end process formalization x Market uncertainty		.29***			
Front-end process formalization x Technology uncertainty			.05		
Outcome-based rewarding x Market uncertainty				.02	
Outcome-based rewarding x Technology uncertainty					-.10
R^2	.25	.32	.26	.25	.26
Adjusted R^2	.16	.23	.15	.15	.16
F	2.64**	3.52***	2.48**	2.46**	2.55**
Sig. of F change		.00***	.55	.79	.27

* $p \leq .10$; ** $p \leq .05$; *** $p \leq .01$
Standard coefficient betas are shown
Dependent variable: product concept superiority
Hypothesized paths one-tailed tests, control variables two-tailed tests

Hypotheses H1a–H7a were tested with Model 1 as in Table 25. Hypothesis H1a, that input control has a positive association with product concept superiority, is not supported. Non-significant negative association was found in testing with Model 1. IH2a hypothesized that front end process formalization is negatively associated with product concept superiority. This hypothesis can be rejected since significant positive association was found (beta = .20, $p \leq .05$). In other words, the opposite hypothesis would have gained support in the light of this data.

Hypothesis H3a, which predicted a negative association between outcome-based rewarding and product concept superiority, is not supported either. The association is indeed negative but non-significant. Hypothesis H4a is supported; strategic vision is positively associated with product concept superiority (beta = .23, $p \leq .05$). Hypothesis H5a stated that informal communication is positively associated with product concept superiority. This is not supported since a negative and non-significant relationship was found. Hypothesis H6a, which predicted a positive association between participative planning and product concept superiority, needs to be rejected. A negative and non-significant relationship was found in Model 1. Finally, hypothesis H7a stated a positive association between intrinsic task motivation and product concept superiority. This hypothesis gets marginal support and can be accepted with caution (beta = .14, $p \leq .1$). In addition, four significant control variable effects can be found in Model 1: firm size has a significant negative effect on product concept superiority (beta = -.26 $p \leq .05$); R&D intensity has a significant positive effect on product concept superiority (beta = .24, $p \leq .05$); the piece good industry has a marginally significant positive effect on product concept superiority (beta = .25, $p \leq .1$); and the process-based production industry a significant positive effect on product concept superiority (beta = .27, $p \leq .05$).

R and F values, indicating overall explanatory power of the model and the adequacy of the model respectively, are reported at the end of Table 25. The adjusted R^2 value, which takes into account the number of independent variables and the sample size, indicates reasonable explanatory power (R^2 = .16), i.e. that the variables reasonably explain the variation in the product concept superiority variable. An F-test was used to test the significance of the overall regression model. The F value of Model 1 in Table 25 is statistically significant. Predictor value centering was applied to tackle problems

of multicollinearity. The highest VIF values were with the piece good industry (2.66) and the process-based production industry (2.81), therefore multicollinearity was not a problem in Model 1.

Hypotheses H8a and H8b were tested with Model 2 and Model 3 respectively, presented in Table 25. Model 1 in the table represents a comparison model where the influence of the moderating effect is compared. Hypothesis H8a stated that the more market uncertainty, the more negative the association between front end process formalization and product concept superiority. Model 2 does not suffer from high multicollinearity (highest VIF 2.81). Model 2 also has good explanatory power (R^2 = .23). The standardized coefficient beta for the moderated variable (front end process formalization x market uncertainty) is .29 with strong statistical significance. Both the F value and change in F value (.00) have strong statistical significance. Since hypothesis H8a predicted more negative association, it needs to be rejected. Yet the opposite hypothesis would have been strongly supported.

Hypothesis H8b, which was tested with Model 3 as in Table 25, stated that the more technology uncertainty, the more negative the association between front end process formalization and product concept superiority. The VIF values indicate that multicollinearity was not a problem in Model 3 (highest VIF 2.81). The adjusted R^2 value in turn indicates that Model 3 has reasonable explanatory power (R^2 = .15). The standardized coefficient beta for the moderated variable (front end process formalization x technology uncertainty) is .05, which is not statistically significant. The F value of Model 3 is statistically significant. However, the F value change (compared to Model 1) is not (.55), and thus hypothesis H8b needs to be rejected.

Hypothesis H9a was tested with Model 4 and hypothesis H9b with Model 5 as in Table 25. Model 1 again represents a comparison model where the influence of the moderating effect is compared. Hypothesis H9a, that under high market uncertainty the association between outcome-based rewarding and product concept superiority is more negative, is not supported. The VIF values indicate that multicollinearity was not a problem in Model 4 (highest VIF 2.87). The adjusted R^2 value indicates that Model 4 has reasonable explanatory power (R^2 = .15). The standardized coefficient beta for the moderated variable (outcome-based rewarding x market uncertainty) is

.02, which is not statistically significant. The F value of Model 4 is statistically significant. However, the F value change is not statistically significant (.79). Thus hypothesis H9a can be rejected. Hypothesis H9b stated that the more technology uncertainty, the more negative the association between outcome-based rewarding and product concept superiority. The highest VIF value is 2.81, which again indicates that multicollinearity was not a problem in Model 5. Model 5 has reasonable explanatory power (R^2 = .16). The standardized coefficient beta for the moderated variable (outcome-based rewarding x technology uncertainty) is -.10. This is not statistically significant. The F value of Model 5 is statistically significant but the F value change is not (.27). Based on this, hypothesis H9b should be rejected.

5.3.2 Regression analyses for strategic renewal

Testing of hypotheses H1b-H7b, H8c and H8d, and H9c and H9d with the strategic renewal model is shown in Table 26. The first column shows the independent, control and moderated variables entered in the regression model. The model column gives the standardized beta coefficients and their significance levels for each variable. For the hypothesized paths, the significance test is one-tailed. For the control variables, the significance test is two-tailed. All the independent variables were entered simultaneously in the regression models when testing the hypothesized direct relationships. Predicted moderated relationships were tested one at a time. Entering the base line model (only control variables) into the regression analysis gives the following results: $R^2 = .26$, adjusted $R^2 = .21$, $F = 5.34$, $p \leq .05$.

Table 26. Results of regression analyses for strategic renewal.

Variables entered	Model 6	Model 7	Model 8	Model 9	Model 10
Independent variables					
Input control	.22***	.22***	.23***	.22**	.23***
Front-end process formalization	-.04	-.03	-.04	-.04	-.01
Outcome-based rewarding	-.07	-.07	-.05	-.07	-.05
Strategic vision	.01	.02	.01	.01	.04
Informal communication	-.08	-.07	-.08	-.07	-.07
Participative planning	-.01	-.01	-.01	-.01	-.04
Intrinsic task motivation	.21***	.21***	.20***	.21***	.19**
Control variables					
Market uncertainty	.39***	.39***	.36***	.40***	.36***
Technology uncertainty	.18**	.18**	.18**	.17*	.18**
Size	.07	.07	.06	.07	.06
R&D intensity	.05	.04	.06	.05	.04
Piece good industry	.23*	.22*	.20	.23*	.19
Process-based production industry	.10	.09	.10	.11	.09
Objectives of the development project	-.12	-.12	-.11	-.13	-.12
Definition of the front-end process	-.09	-.09	-.06	-.09	-.08
Moderated variables					
Front-end process formalization x Market uncertainty		-.03			
Front-end process formalization x Technology uncertainty			-.14**		
Outcome-based rewarding x Market uncertainty				-.06	
Outcome-based rewarding x Technology uncertainty					-.16**
R^2	.34	.34	.35	.34	.36
Adjusted R^2	.25	.24	.26	.25	.27
F	3.92***	3.67***	3.93***	3.70***	4.01***
Sig. of F change		.67	.09*	.47	.05**

* $p \leq .10$; ** $p \leq .05$; *** $p \leq .01$
Standard coefficient betas are shown
Dependent variable: strategic renewal
Hypothesized paths one-tailed tests, control variables two-tailed tests

Hypotheses H1b–H7b were tested with Model 6 as in Table 26. Hypothesis H1b is supported. A statistically strong significant positive association (beta = .22, $p \leq .01$) was found between input control and strategic renewal in the test with Model 6. Hypothesis H2b is not supported; H2b hypothesized that front end process formalization is negatively associated with strategic renewal. The association is negative but non-significant. Hypothesis H3b stated a negative association between outcome-based rewarding and strategic renewal. The association is indeed negative but non-significant. Thus hypothesis H3b is rejected. Hypothesis H4b, which stated that strategic vision is positively associated with strategic renewal, is not supported. The association is positive but non-significant, and the hypothesis should be rejected. Hypothesis H5b predicted that informal communication is positively associated with strategic renewal. This is not supported either since a negative and non-significant relationship was found. Hypothesis H6b, which predicted a positive association between participative planning and strategic renewal, needs to be rejected. A negative and non-significant relationship was found in Model 6. Finally, hypothesis H7b, that there is a positive association between intrinsic task motivation and strategic renewal, is strongly supported (beta = .21, $p \leq .01$). In addition, three significant control variable effects can be found in Model 6: market uncertainty (beta = .39 $p \leq .01$) has a statistically significant positive effect on strategic renewal; technology uncertainty (beta = .18 $p \leq .05$) has a statistically significant positive effect on strategic renewal; and the piece good industry has a marginally significant positive (beta = .23, $p \leq .1$) effect on strategic renewal.

Model 6 has good explanatory power (adjusted R^2 = .25). An F-test was used to test the significance of the overall regression model. The F value of Model 6 in Table 26 is statistically significant. Predictor value centering was applied to tackle problems of multicollinearity. The highest VIF values were with the piece good industry (2.66) and the process-based production industry (2.81).

Hypotheses H8c and H8d were tested with Model 7 and Model 8 respectively, as presented in Table 26. Model 6 represents a comparison model where the influence of moderating effect is compared. Hypothesis H8c stated that the more market uncertainty, the more negative the association between front end process formalization and strategic renewal. Model 7 does not suffer from high

multicollinearity (highest VIF 2.81). Model 7 also has good explanatory power (R^2 = .24). The standardized coefficient beta for the moderated variable (front end process formalization x market uncertainty) is -.03, which is not statistically significant. The F value for the model is statistically significant, but the change in F value (.67) is not. Thus, hypothesis H8c can be rejected.

Hypothesis H8d, tested with Model 8 as in Table 26, predicted that the more technology uncertainty, the more negative the association between front end process formalization and strategic renewal. The VIF values indicate that multicollinearity was not a problem in Model 8 (highest VIF 2.81). The adjusted R^2 value indicates that Model 8 has reasonable explanatory power (R^2 = .26). The standardized coefficient beta for the moderated variable (front end process formalization x technology uncertainty) is -.14, which is statistically significant. The F value of Model 8 is statistically significant. The F value change has marginal statistical significance (.09) and thus hypothesis H8d gains support. However, the result needs to be interpreted with caution.

Hypothesis H9c was tested with Model 9 as in Table 26. The hypothesis predicted that there is a more negative association between outcome-based rewarding and strategic renewal under high market uncertainty; this is not supported. The VIF values indicate that multicollinearity was not a problem in Model 9 (highest VIF 2.87). The adjusted R^2 value indicates that Model 9 has good explanatory power (R^2 = .25). The standardized coefficient beta for the moderated variable (outcome-based rewarding x market uncertainty) is -.06, which is not statistically significant. The F value of Model 9 is statistically significant; however, the F value change is not (.47). Thus hypothesis H9c can be rejected.

Hypothesis H9d stated that the more technology uncertainty, the more negative the association between outcome-based rewarding and strategic renewal. This hypothesis was tested with Model 10 as in Table 26. The highest VIF value was 2.81, which indicates that multicollinearity was not a problem. Model 10 has good explanatory power (R^2 = .27). The standardized coefficient beta for the moderated variable (outcome-based rewarding x technology uncertainty) is -.16; this is statistically

significant ($p \leq .05$). The F value of Model 10 is statistically significant, as is the F value change ($p \leq .05$). Based on this, the hypothesis H9d is supported.

5.3.3 Summary of results

The results from the hypotheses testing are summarized in Table 27. Altogether, 22 hypothesized relationships were tested with 10 different regression models. The results indicate that four hypotheses are supported, two hypotheses are marginally supported, and 16 hypotheses are not supported. Among these 16 rejected hypotheses, in two situations the opposite hypotheses would have gained support. The fact that the majority of these theory-based hypotheses need to be rejected indicates that existing theory related to management control in the front end of innovation is far from being complete.

Table 27. Summary of hypotheses tests and results.

	Description of hypotheses	Result
	Product concept superiority	
H1a	Input control is positively associated with product concept superiority.	Not supported
H2a	Front-end process formalization is negatively associated with product concept superiority.	Not supported. Opposite hypothesis is supported
H3a	Outcome-based rewarding is negatively associated with product concept superiority.	Not supported
H4a	Strategic vision is positively associated with product concept superiority.	Supported
H5a	Informal communication between management and a front-end group is positively associated with product concept superiority.	Not supported
H6a	Participative planning is positively associated with product concept superiority.	Not supported
H7a	Intrinsic task motivation is positively associated with product concept superiority.	Marginally supported
H8a	The more market uncertainty, the more negative the association between front-end process formalization and product concept superiority.	Not supported. Opposite hypothesis is supported
H8b	The more technology uncertainty, the more negative the association between front-end process formalization and product concept superiority.	Not supported
H9a	The more market uncertainty, the more negative the association between outcome-based rewarding and product concept superiority.	Not supported
H9b	The more technology uncertainty, the more negative the association between outcome-based rewarding and product concept superiority.	Not supported
	Strategic renewal	
H1b	Input control is positively associated with strategic renewal.	Supported
H2b	Front-end process formalization is negatively associated with strategic renewal.	Not supported
H3b	Outcome-based rewarding is negatively associated with strategic renewal.	Not supported
H4b	Strategic vision is positively associated with strategic renewal	Not supported
H5b	Informal communication between management and a front-end group is positively associated with strategic renewal.	Not supported
H6b	Participative planning is positively associated with strategic renewal.	Not supported
H7b	Intrinsic task motivation is positively associated with strategic renewal.	Supported
H8c	The more market uncertainty, the more negative the association between front-end process formalization and strategic renewal.	Not supported
H8d	The more technology uncertainty, the more negative the association between front-end process formalization and strategic renewal.	Marginally supported
H9c	The more market uncertainty, the more negative the association between outcome-based rewarding and strategic renewal.	Not supported
H9d	The more technology uncertainty, the more negative the association between outcome-based rewarding and strategic renewal.	Supported

6 DISCUSSION

***"Leaders establish the vision for the future and set the strategy for getting there; they cause change. They motivate and inspire others to go in the right direction and they, along with everyone else, sacrifice to get there."* – John Kotter**

Two different measures were used to investigate front end performance in this study, one of which was more short-term-oriented, well framed and focused on intermediate results (product concept superiority), and the other which was more long-term and forward looking (strategic renewal). The results show that management control mechanisms contribute to performance in different ways depending on the performance variable used, thus supporting previous research[665]. Explanations for these differences are discussed in the following subchapters.

This discussion chapter is divided into four parts. First, results from management control in terms of product concept superiority are discussed. The second part discusses findings from management control in terms of strategic renewal. Third, results from the hypothesized moderated relationships are reviewed. Finally, the situation where both product concept superiority and strategic renewal are in focus is discussed.

6.1 Management control and product concept superiority

Management has many options to control the front end of innovation to ensure that the created product concepts are adequately differentiated among competing products and to create competitive advantage for the company and enlightening experiences for customers. A holistic measurement model was developed including those input, process and output control modes emphasized in the literature and also the more informal mechanisms of strategic vision, informal communication, participative planning, and intrinsic task motivation.

6.1.1 The role of management control in product concept superiority

The results showed that certain management control mechanisms can significantly contribute to product concept superiority, but still they explain only a part of the

[665] Kirsch 1996

variance of performance (adjusted R^2 = .16). In other words, management has an important role in contributing to product concept superiority, but there are also other important influencing factors not covered in this study. For example, originality and novelty embodied in an identified opportunity and idea have a great influence themselves on how the front end project proceeds and how successful the final outcome is[666]. Creativity, which can be influenced by the organizational work environment, is the seed of all novel and useful ideas that eventually lead to successful innovations[667]. In addition, several front end activities as such contribute to successful product concepts. For example, detailed customer needs analysis[668] and preliminary market and technology assessment[669] are found to be critical in terms of successful new product concepts. Further, proficiency in idea screening[670] to select the most promising ideas and concept testing[671] to eliminate poor concepts is critical in terms of superior product concepts. Front end group members are obviously quite capable of building the best possible new product concepts without any management intervention. That is the job that they are hired for and are motivated to do. A physically separated 'skunk works', in which the team is empowered to make all critical decisions and management has a supportive and consultative role only when requested, are examples of this kind of development approach[672].

Three significant control variable effects were also observed in the results. First, firm size was negatively associated with product concept superiority. This is in line with earlier findings that smaller firms are more successful than large firms because the products are typically designed for the more specific needs of a target group or built directly for a customer under a defined contract[673]. Bigger firms also have more resources for trial-and-error development in the front end compared to smaller firms, which need to be more careful when selecting which opportunities to pursue. Second, R&D-intensity was positively associated with product concept superiority. This was to be expected since many R&D-intensive firms invest more resources also to the

[666] Kim and Wilemon 2002
[667] Amabile et al. 1996
[668] Bacon et al. 1994, Khurana and Rosenthal 1998
[669] Khurana and Rosenthal 1998, Cooper 1994
[670] Dwyer and Mellor 1991, Cooper Kleinschmidt 1987
[671] Lees and Wright 2004, Crawford and Di Benedetto 2000
[672] Single and Spurgeon 1996
[673] Murphy and Kumar 1996

front end of innovation enabling more thorough conceptualization work and more successful outcomes[674]. Third, the process-based production industry was positively associated with product concept superiority. The reason for this could be that the process-based production industry is a more capital-intensive industry compared to others and it has to be more carefully considered whether product concepts have enough business potential to justify the necessary investment.

6.1.2 Management control mechanisms promoting product concept superiority

Of the investigated management control mechanisms, front end process formalization, strategic vision, and intrinsic task motivation turned out to be critical mechanisms contributing to superior product concepts.

The results showed that front end process formalization is positively associated with product concept superiority (Hypothesis H2a). Front end process formalization may not only have positive effects on front end performance. However, the results indicate that advantages created by process formalization, such as improved focus, steering, learning and coordination[675], overcome the potential challenges of decreased innovativeness and flexibility, increased bureaucracy, the use of shortcuts, and negative attitudes[676], created by a structured and formalized approach. That is, a potential decrease in e.g. innovativeness or intrinsic motivation is compensated for by an increased ability to make systematic and coordinated decisions even in the context of uncertainty and even chaotic behavior. The results indicate that speculation between front end process formalization and decreased performance is questionable if the product concept is used to define performance. This speculation may be caused by inadequate understanding of characteristics of the front end phase and of appropriate means of formalizing, e.g. different types of front end process models[677]. A process can provide competitive advantage only if fine-tuned to fit the company-specific context and having full buy-in among development personnel[678].

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[674] Alves et al. 2007
[675] Bonner et al. 2002, Tatikonda and Rosenthal 2000, Ulrich and Eppinger 2003, Hertenstein and Platt 2000, McGrath 1996
[676] Tatikonda and Rosenthal 2000, Hertenstein and Platt 2000, Amabile 1998, McGrath 1996, Bonner et al. 2002
[677] See Chapter 2.3.1
[678] Kleinschmidt et al. 2007, Cooper 1998

Development of the formal front end process is one critical step toward effective management control for four important reasons: coordination, timing, focus and market emphasis. First, front end process formalization helps to combine different types of expertise in a coordinated manner. NPD is increasingly decentralized due to companies transferring operations closer to important markets[679] and capturing the best knowledge potential from multiple locations[680], thus creating more coordination challenges. A formalized process clarifies the roles of different functions, gives a basic structure for cross-functional communication, and enables different functions to bring their competence and knowledge to the development effort in a timely manner[681]. Efficient coordination between R&D, sales and marketing, and production has been noted as critical to innovation success in the NPD context in general[682]. Second, the formalized front end process gives management the time and place to influence critical decisions. More active involvement of management with in-depth understanding of past front end project decisions contribute to knowledge transfer between front end projects and adds "front-loading", which has been associated with development performance in previous studies[683]. The existence of specific review points decreases the probability that senior management get too involved, i.e. too deeply, in operative decision-making, which is further associated with poor performance in previous studies[684]. Third, existing process structures enable managers and development personnel to focus their energy on the most critical development issues and to trust the guidance and direction given by the formal process in everyday issues[685]. Even though formalization may decrease individual, spontaneous creativity[686], the creativity of a group of individuals representing different functions and creativity by demand, i.e. in a specific situation that is needed to advance novel ideas, is better harnessed. Finally, front end process formalization helps to ensure that no critical activity is passed. A clearly defined development process helps to ensure that each step is thoroughly accomplished, resulting in high quality end results[687].

[679] Gassmann and von Zedtwitz 2003
[680] Hoegl et al. 2007, Gassmann and von Zedtwitz 2003
[681] Ulrich and Eppinger 2003
[682] Zirger and Maidique 1990
[683] Thomke and Fujimoto 2000
[684] Bonner et al. 2002, Gerwin and Moffat 1997
[685] McGrath 1996
[686] Amabile 1998
[687] Ulrich and Eppinger 2003

High-tech firms especially are often R&D dominated[688] leading to an engineering-driven culture, which may diminish the emphasis on processing customer- and competitor-related information or using customer information, both of which have been linked with the creation of product advantage in earlier studies[689].

The research results[690] that show a negative relationship between process formalization and development project performance need to be critically evaluated in the light of the present findings. Actually, it could be assumed that a development project phase, which is a more mechanistic implementation of existing plans compared to the front end phase, would benefit from formalization even more. The fact that hypothesis H2b, which stated that process formalization has a negative association with strategic renewal, was not supported, is a strong indication that process could and should be formalized to some extent in the front end of innovation. The findings indicating that a greater degree of formality in NPD projects in general leads to project execution success[691] holds also for the front end of innovation. Process formalization is the way to ensure that promising opportunities are advanced in the pipeline toward solid product concepts and that management gets well-studied and thoroughly analyzed concepts for decision-making.

It can also be speculated whether the nature of product concept superiority as a performance variable influences the results in terms of process formalization. Product concept superiority is a relatively well-framed performance measure, short-term focused and easy to evaluate in the light of the given criteria. When the end result of the front end of innovation is relatively easy to define, it is also easier to develop a process that ensures that those critical issues of the product concept are adequately considered during the development process. In other words, criteria used to define 'superiority' steer the front end activities toward the goal and are thus part of front end process formalization. This speculative explanation is one avenue for future studies to investigate the benefits of front end process formalization further.

[688] Workman 1993
[689] E.g. Li and Calantone 1998
[690] See e.g. Bonner et al. 2002, Abernethy and Brownell 1997
[691] Tatikonda and Rosenthal 2000

Besides formalizing the front end process, management should actively apply strategic vision to achieve superior product concepts (hypothesis H4a). Practitioners sometimes state that strategic vision, like other value-based control mechanisms, is a useless management fad and underestimate its influence. However, the results show that strategic vision positively influences on front end success e.g. by giving consensus and common direction for front end activities, by removing confusion and conflicting agendas and enabling faster decision-making[692], thus supporting earlier findings done in the NPD context in general. Employees are typically eager to work hard toward a compelling and inspiring vision[693] and to stress their capabilities in order to realize aspirations. The lack of a clear vision in the front end of innovation, where decision-making situations and options for consideration are often fuzzy and based on speculative information, may lead to slow development cycles and idle motion where the front end projects are not actively promoted. Without a clear vision any direction would make sense, causing unfocused development interventions. The positive influence provided by a well-articulated vision is likely due to the alignment of decisions between different functions than inside a single function. In addition, strategic vision aids people working in boundary spanning and gatekeeper roles to make sense of relevant information to be shared forward in the organization[694]. It is already known that strategic vision greatly influences which types of ideas get supported and championed in the organization[695]. The results of this study show that strategic vision contributes to the achievement of superior product concepts in the front end of innovation.

In particular, the results emphasize the important role of intrinsic task motivation of front end group members in order to achieve superior product concepts (hypothesis H7a). Besides providing a compelling strategic vision and giving a formal process structure for the front end of innovation, what managers can do is to allow freedom for the front end group and rely on its motivation and self-management in operative matters. Increased motivation gives employees extra stimulus to work hard and persistence to attain organizational goals, further leading to increased performance[696].

[692] Zhang and Doll 2001, Englund and Graham 1999, McGrath 1996
[693] Kotter 1990
[694] Reid and de Brentani 2004
[695] Marginson 2002
[696] Manz 1986, Thomas and Velthouse 1990

Intrinsic task motivation has also been related to empowerment and the transfer of decision-making responsibilities to those people who are actually executing the work[697]. Empowerment additionally has a positive effect on creativity in problem solving, learning, and the speed of decision-making, which are all critical in the front end of innovation[698]. The findings on the necessity of intrinsic task motivation on product concept superiority supports previous research by stressing the importance of individual self-control[699] and team empowerment[700], especially in the context of uncertainty, non-routine and complex tasks, tasks requiring creativity and intellectual activities, and in the early phase of the innovation process[701]. Decision-making authority creates ownership and the feeling of responsibility, which encourages team members to use their maximum capacity or even exceed and stretch their capabilities. The results indicate that both formality and flexibility are needed[702] to create superior product concepts. While formality brings structure and an overall framework to the front end work, flexibility concerning individual work activities and empowerment in terms of operative decisions enable reflection on the special needs of a front end project and also the needs of development personnel. Besides granting empowerment and autonomy for certain decisions, management can contribute to self-control and intrinsic task motivation by using belief systems (showing a compelling vision, communicating values and inspiring individuals), cultivating the right organizational culture and working environment, giving appropriate feedback, communicating the value of self-control, and training those competences needed for self-control[703]. In some cases, just giving those development-focused employees the room and opportunity to pursue promising opportunities in the middle of a tight project and efficiency culture is enough to nourish their intrinsic task motivation.

The results make intrinsic task motivation the focal point while selecting and allocating human resources in the front end. Typically, the emphasis has been on the knowledge and capability levels of employees when considering front end

[697] Manz 1986, Thomas and Velthouse 1990, Luthans and Davis 1979, Amabile 1998
[698] Imai et al. 1985, Smith and Reinertsen 1998
[699] Manz and Sims 1980, Manz 1986, Thomas and Velthouse 1990, Luthans and Davis 1979, Uhl-Bien and Graen 1998, Hartman and Vaassen 2003
[700] Tatikonda and Rosenthal 2000, Smith and Reinertsen 1998, Wheelwright and Clark 1992, McGrath 1996, Amabile 1998
[701] Mills 1983, Govindarajan 1988, Otley 1994, Kirsch 1996, Kirsch 2004
[702] Tatikonda and Rosenthal 2000, Eisenhardt and Tabrizi 1995
[703] Simons 1997, Kirsch 1996, Mills 1983, Manz 1986, Imai et al. 1985

resources[704]. In the light of the results, it can be argued that individual motivation to engage in the development of product concepts in a task environment of high uncertainty, confusion and lack of clarity should be highlighted as a selection criterion of optimal resources.

6.1.3 Variables not associated with product concept superiority

From the hypothesized relationships, input control (H1a), outcome-based rewarding (H3a), informal communication (H5a) and participative planning (H6a) were not found to be associated with product concept superiority. Input control does not have a significant role in short-term front end performance, but the role is considerable in terms of long-term performance – as will be discussed in the context of strategic renewal. It can be argued that projects contributing to product concept superiority are more straightforward and there are more people who have adequate competence levels to accomplish these projects compared to projects aiming at strategic renewal[705], thus mitigating the benefits of input control. A mediated relationship could provide another plausible explanation. Resource commitment in the form of providing sufficient resources has been found to be positively associated with the capabilities needed in front end activities that further have a positive impact on NPD program performance[706].

Outcome-based rewarding was expected to have a negative influence on front end performance due to difficulties in evaluating outcomes objectively[707] and many negative group-level influences[708], but the results showed the negative relationship only context of high technology uncertainty when pursuing strategic renewal. These results are supported by previous research, which has not found any relationship between reward system and project performance[709], or rewarding and quality of output[710]. The other plausible explanation is that intrinsic task motivation is more important than external rewards, as indicated by the results of this study and some

[704] Kim and Wilemon 2002, Cagan and Vogel 2002
[705] Stevens and Burley 2003
[706] Kleinschmidt et al. 2007
[707] Rockenss and Shields 1988
[708] Bartol and Srisastava 2002, Jenkins Jr. et al. 1998, Amabile et al. 1996, Ramaswami 1996, Simons 1995, Snell 1992
[709] Bonner et al. 2002
[710] Jenkins Jr. et al. 1998

earlier studies[711]. However, associations other than linear relationships should be explored in future studies to better understand the use of output controls in the front end of innovation.

Informal communication was not associated with product concept superiority. Previous research indicates that informal control methods are used in the front end of innovation[712] and general management control literature suggests using informal control methods such as informal communication to counteract weaknesses or challenges of formal control methods[713]. The results indicate that even though informal communication and product concept superiority are not associated, there is a positive correlation between informal communication and formal input control and front end process formalization, supporting the idea of complementary usage of informal and formal control mechanisms. Complementary usage would enable some of the typically mentioned advantages of informal communication, critical in the front end of innovation, to be gained, such as getting real-time information or enabling early problem elimination[714]. The other plausible explanation for these results could be that the focus of communication matters more than intensity[715]. The value of management's input into front end activities arises from the right timing and focusing on the right topic rather than the amount of discussion.

Participative planning between management and front end group members was not associated with product concept superiority. The critical distinction seems to be the level at which employees are involved. The results show that employees are not capable of assisting management in defining strategic objectives or control procedures for front end initiatives in terms of front end performance. That is, there are other positive effects (such as intrinsic task motivation) from the involvement, but no direct relationship between involvement and front end performance. This lends support to previous findings indicating that participative planning is associated with team goal commitment but goal commitment is not connected with the effectiveness or

[711] Amabile 1998
[712] Kirsch 2004
[713] Bisbe and Otley 2004
[714] McGrath 1996
[715] Kleinschmidt et al. 2007

efficiency of teams, especially in the case of incremental projects[716]. The results are also in accordance with previous results from NPD projects indicating that employees' involvement in operative decisions is positively associated with NPD project performance, but regarding strategic decisions employees are not well positioned in the organization to help management in these tasks[717].

The non-existing association between informal communication and participative planning and product concept superiority challenges the theoretical management control framework used in this study[718]. It can be questioned whether the level of formality or level of interactivity should be treated as distinct dimensions of management control as defined in Hales's model, or as integral parts of e.g. input or process control modes. The other potential explanation is that the created independent variables were not able to capture the essence of informality or interactivity. However, this is something that should be considered when using Hales's management control framework in future studies.

6.2 Management control and strategic renewal

Management can control the front end of innovation to enable new market entries, open up NPD opportunities, and intensify learning and creation of new know-how. Again, seven management control mechanisms were studied including input, process and output control modes, and also more informal mechanisms of strategic vision, informal communication, participative planning and intrinsic task motivation.

6.2.1 The role of management control in strategic renewal

The results showed that management control can significantly contribute to strategic renewal and the model explains a reasonable part of the variance of performance (adjusted R^2 = .25). However, there are also several other factors that influence strategic renewal. For example, the original opportunity and idea have a critical impact on the amount of strategic renewal. The more novel or creative the original idea is from the viewpoint of the organization, the more capacity the front end project

[716] Hoegl and Parboteeah 2006
[717] Bonner et al. 2002
[718] Hales 1993

has for renewing strategy[719]. This is supported by two significant control variable effects that were observed in the empirical results. Both market and technology uncertainties were positively associated with strategic renewal. This was expected since the renewal of strategy typically includes dealing with idea with unfamiliar markets and the development of novel technologies.

The proficiency of execution of front end activities has an impact on strategic renewal. Market appraisals, financial analyses and product definitions have been associated with the ability to create windows of new opportunities[720]. In addition, opportunity recognition and concept selection have been identified as critical by previous studies[721]. Front end activities are executed done by a group of people and the quality of the team work has been found to be an important performance driver in innovative projects[722]. Open communication, mutual support and team cohesion are examples of factors contributing to team performance. Timing is also a critical issue. For example, the stage of lifecycle or S-curve[723] of adopted technology in the product may greatly impact whether the product succeeds and contributes to strategic renewal[724]. The concept may be too futuristic or too traditional to succeed depending on timing and technology adoption in the markets in general. In addition, the selected competitive strategy prioritizes innovations and defines the level of renewal pursued at a company level. Earlier findings suggest that a strategy process, statement of competitive strategy and innovation orientation in general significantly affects the level of innovativeness of a firm and its capability of renewal[725].

6.2.2 Management control mechanisms promoting strategic renewal

The results show that managers have the greatest opportunity to influence strategic renewal particularly through resource allocation and task assignment, i.e. controlling inputs and at the same time allowing the front end group sufficient freedom to pursue its intrinsic motivations.

[719] Kim and Wilemon 2002, Amabile et al. 1996
[720] Kleinschmidt et al. 2007
[721] Kleinschmidt et al. 2005
[722] Hoegl and Gemuenden 2001
[723] Foster 1986
[724] Herrmann et al. 2007
[725] Siguaw et al. 2006, Bart 1998

The findings showed that input control was positively associated with strategic renewal in the front end of innovation (hypothesis H1b). This supports previous research that emphasizes a clear focus on development work and sharing strategic goals in the front end of innovation[726], selecting the right leaders and front end groups[727], and emphasizing input control when the development process includes ambiguity[728]. The importance of input control in the front end of innovation draws attention to two issues. First, by engaging in input control through specific and challenging goals, managers enable the front end group to accept and take risks that are necessary for strategic renewal. By setting boundaries for accepting and tolerating uncertainty, managers give both direction and support to the front end group. The results are supported by psychological research that indicates that employees are more likely to produce novel and radical ideas if they are explicitly requested[729]. Previous research has also reported that pre-project business planning is associated with proficient project risk planning, which in turn is related to innovation success[730], and that the team's commitment to goals is associated with better performance in more innovative projects[731]. The results contribute by providing evidence purely centering on the front end of innovation, and indicating that specific and challenging goals as outlined in goal-setting theory[732] lead to higher performance also in non-routine environments pursuing strategic renewal. The results corroborate previous arguments that a clear focus of the development effort, understanding and consensus on strategic goals, and increased commitment for a given task increase the likelihood of successful outcomes in the front end context[733]. In addition, the results verify that management should indeed be actively involved in the front end projects in their early stages[734].

Second, when allocating resources to manage and execute the front end task, managers control innovation by assigning creativity, capability and capacity to the innovation task. The results are supported by previous research that emphasizes the

[726] McDonough 2000, Zhang and Doll 2001, Hoegl and Parboteeah 2006, Ulrich and Eppinger 2003, Cooper 1998
[727] Stevens and Burley 2003, Kim and Wilemon 2002, Smith and Reinertsen 1998, McGrath 1996, Brown and Eisenhardt 1995, Dougherty 1992
[728] Rockness and Shields 1984
[729] Parnes 1964
[730] Salomo et al. 2007b
[731] Hoegl and Parboteeah 2006
[732] Locke 1968, Locke and Latham 1990, Campbell and Furrer 1995
[733] Ulrich and Eppinger 2003, Davila 2000, Zhang and Doll 2001
[734] Smith and Reinertsen 1998, McGrath 1996, Wheelwright and Clark 1992

importance of group leader selection and allocation in order to provide capacity for lobbying resources, keeping chaos within tolerable limits and translating vision into action[735]. However, management should not only nominate the optimal project manager, but also make sure that the innovation task is carried out in a cross-functional team with a sufficiently broad set of knowledge from different disciplines[736]. Previous studies argue that functional diversity inside the teams increases the amount and variety of available information, which further makes the development process quicker and improves performance[737]. The amount and variety of available information and tacit knowledge, as well as cross-fertilization enabled by cross-functionality, increases the likelihood that a concept is based on novel and creative ideas, and that all the relevant aspects of the new product concepts are well refined[738]. The importance of group member selection is even more emphasized when self-organized and empowered development teams are used.

As development teams have become globally dispersed to find optimal and specialized knowledge composition[739], and team work quality is critical in terms of effectiveness in dispersed teams[740], managerial input control seems to be even more critical. The results are in line with previous studies indicating that staffing quality is related to high efficiency and goal achievement[741]. Prior evidence calls for emphasizing, for example, the role of inventors (technology visioning role), ruminators (market visioning role)[742] and champions[743] pursuing radical innovations and renewal. Earlier research has also associated domain-relevant skills and creative-thinking skills with the quality of teamwork[744]. Also, project management skills have been associated with team reflexivity which, in turn, is needed for effectiveness[745]. It has also been argued that ignoring individual preferences and capabilities in resource

[735] Smith and Reinertsen 1998, McGrath 1996, Brown and Eisenhardt 1995, Nonaka 1988
[736] Cagan and Vogel 2002, Kim and Wilemon 2002, Gerwin and Barrowman 2002, Brown and Eisenhardt 1995, Dougherty 1992, Clark and Fujimoto 1991
[737] Brown and Eisenhardt 1995
[738] Kim and Wilemon 2002, Brown and Eisenhardt 1995, Imai et al. 1985
[739] Gassmann and von Zedtwitz 2003
[740] Hoegl et al. 2007
[741] McComb et al. 2007, Hoegl and Gemünden 2001
[742] O'Connor and Veryzer 2001
[743] Leifer et al. 2000
[744] Hoegl and Parboteeah 2007
[745] Hoegl and Parboteeah 2006

allocation is one of the most infallible ways of killing creativity[746], which is vital for strategic renewal. Besides the skills learned, the natural tendencies of a group leader additionally seem to have a critical influence on strategic renewal[747]. The previous study indicates that the personality trait combination "intuition" and "thinking" in the Myers-Briggs Type Indicator scale of a group leader is associated with performance in new business development cases[748]. This is due to the increased ability for creative work that is required for reshaping ideas to find uniqueness and for branching a project in an appropriate direction. In a similar vein, properly staffed teams have been argued as being efficient at adjusting to fast-paced projects due to their ability to quickly understand and realize alternative approaches[749].

In addition to drawing attention to resource control in the front end of innovation in particular, our results are evidence of the importance of the front end of innovation to dynamic capabilities[750] by revealing management's central role in controlling the resource inputs and thereby promoting strategic renewal. A company's resources as such do not provide competitive advantage[751], but allocation of these valuable resources in an appropriate manner makes a difference[752]. Management's ability to adapt and integrate organizational skills and competences, both internal and external[753], in conditions of uncertainty in the front end of innovation is critical to strategic renewal to avoid the emergence of core rigidities[754] and to avoid typical innovation traps caused by excellent performance or lack of commitment[755]. The results are in line with previous evidence suggesting that capacity of transformation competencies increases the capability of introducing radical innovations[756].

While creating new understanding on how management can control inputs in the front end of innovation, the study also opens up new questions and a path for future research. Both task and goal definition and resource allocation fell inside the same

[746] Amabile 1998
[747] Stevens and Burley 2003
[748] Stevens and Burley 2003
[749] Eisenhardt and Tabrizi 1995
[750] Teece et al. 1997, Eisenhardt and Martin 2000, Verona and Ravasi 2003, Salomo et al. 2007
[751] Murray and Donegan 2003
[752] Siguaw et al. 2006
[753] von Stamm 2004
[754] Leonard-Barton 1992
[755] Välikangas and Gibbert 2005
[756] Herrmann et al. 2007

measurement construct in this study. Since input control has a critical role in enabling strategic renewal, it should be studied more thoroughly. For example, separation of resource allocation (front end manager and front end group members) from goal and task definition and studying concept limitations[757] as one type of input control could reveal the main inputs that management should pay attention to.

Besides controlling inputs, the results indicate that management should take care of the intrinsic task motivation of front end group members in order to contribute to strategic renewal (hypothesis H7b). Actually, taking care of intrinsic task motivation was the only management control mechanism that contributed to both performance measures, stressing the importance of nourishing motivation (see Chapter 6.1.2). In the case of pursuing long-term strategic renewal, the motivational aspects are even more emphasized compared to more straightforward short-term results. These types of projects require persistent effort to pursue the final goals and unmotivated employees are likely to lack adequate faith in confronting emerging difficulties and finishing front end projects. This argument is supported by previous studies that have suggested that task motivation is critical in determining the actual level that a person is willing to use of his/her creativity potential[758]. Besides the competence and traits of front end group members and the manager, their own motivation and enthusiasm are critical factors in front end performance[759]. Evidently, further empirical studies are needed to reveal the complex, causal relationships behind intrinsic task motivation and management interventions in the front end of innovation in order to give a more holistic understanding of the different alternatives that management could use to nourish intrinsic task motivation. For example, previous evidence has suggested that goal commitment moderates the relationship of goal-setting and performance[760], and this may indicate that input control and intrinsic task motivation are interrelated.

6.2.3 Variables not associated with strategic renewal

Front end process formalization (hypothesis H2b), outcome-based rewarding (hypothesis H3b), strategic vision (hypothesis H4b), informal communication (hypothesis H5b), and participative planning (hypothesis H6b) had no significant

[757] Ulrich and Eppinger 2003
[758] Amabile 1998
[759] Smith and Reinertsen 1998
[760] Locke and Latham 1990

relationship with strategic renewal. Front end projects aiming at strategic renewal need more free-wheeling and a trial-and-error attitude[761] compared to projects contributing to superior product concepts, and they do not benefit from formal process structures. This is in line with arguments that whereas sustaining innovations benefit from deliberate and analytical process, more disruptive or strategy-shaping innovations are based on a process driven by spontaneity and intuitive understanding[762]. The non-existing relationship calls for more context-specific research. For example, previous evidence has suggested that a project's autonomy as such is not directly associated with success, but the relationship depends on the nature of autonomy used in a specific context[763].

Outcome-based rewarding does not contribute to strategic renewal as a result of lowered risk taking as discussed in Chapter 6.1.3. The high expectations along with strong risks of failure in the case of strategic renewal are not spurred by extrinsic rewards, but are instead fueled by curiosity and intrinsic motivation as indicated in the results and suggested by previous findings[764].

Strategic vision (hypothesis H4b) had no significant relationship with strategic renewal. There are three explanations for this. In the case of front end projects contributing to strategic renewal, the future agenda and strategic vision are just formed in the front end of innovation. That is, front end projects that differ from the current strategic framework do not follow a strategic vision, but moreover, shift the strategic focus in a new direction. Second, if the strategic vision already exists when new strategy renewing projects are advanced, the vision could detrimentally influence projects by narrowing the alternative too much. The vision may become 'tunnel vision', disregarding some ideas and decreasing the spectrum of alternative options[765]. This is further supported by recent findings that the ability to branch existing ideas into new directions when confronting sudden challenges or obstacles, is one of the key success factors in new business development projects[766]. Third, the non-existing relationship could mean that a challenged and reshaped vision is successfully

[761] Moneart et al. 1995
[762] Christensen et al. 2002
[763] Martinsuo and Lehtonen 2008
[764] Osterloh and Frey 2000
[765] McGrath 2001
[766] Stevens and Burley 2003

translated into front end goals via input control, which promotes success as such without a need to repeatedly interpret the vision.

Informal communication and participative planning do not contribute to strategic renewal as a result of the complementary nature of informal controls, and the inability of front end groups to assist in defining strategic objectives, as discussed in Chapter 6.1.3. In addition, informal communication and participative planning can be considered factors that do not contribute to performance as such, but the lack of these management control mechanisms could have a detrimental effect on front end performance. For example, participative planning had a strong correlation with strategic vision and front end process formalization, which may indicate that participative planning is actively promoted to make the strategic vision more understandable and the front end process more human-oriented. In addition, the possible more complex mediated relationship may provide an explanation for the results. Previous evidence suggests that participative planning increases goal commitment[767], and that commitment to goals is critical in highly innovative projects[768]. Previous findings also indicate that the interactive use of management control mechanisms leads to greater product innovativeness in technical development projects, which further contributes to better project performance[769]. Furthermore, companies with minimal informal communication between the management and employees would probably suffer from hierarchically distant and vague strategic goals. Informal communication also had a strong correlation with input control, emphasizing the importance of informal interaction when starting front end projects. The results are surprising in the light of earlier evidence that clearly highlights the advantages of intense communication between NPD teams and their environment[770], the need for management consultation in operative decisions during the project[771], and the positive influence informal communication between the management and development teams[772] has on success. However, the results support the

[767] Ramaswami 1996
[768] Olson et al. 1995
[769] Ylinen 2004
[770] Ancona and Caldwell 1992
[771] Hoegl and Parboteeah 2006b
[772] Harborne and Johne 2003

complementary nature of informal communication and formal control mechanisms as underlined by previous findings[773].

The non-significant impacts of many control mechanisms open up avenues for further research. For example, non-linear relationships or mediated relationships should be explored to better understand the use of these control mechanisms in the front end of innovation. In addition, interrelationships between different control mechanisms in the form of company-specific control strategies and their possible impact on performance outcomes should also be investigated to increase understanding of the complex nature of management control in the front end of innovation.

6.3 Moderating role of market and technology uncertainty on front end performance

The results indicate that under high market uncertainty the positive relationship between front end process formalization and product concept superiority is even stronger (hypothesis H8a). High market uncertainty calls for intense collaboration between the R&D and sales and marketing functions and the results can be explained through the improved coordination and communication enabled by process formalization. The defined formal execution model clarifies the roles of different functions and enables different functions to bring their competence and knowledge to the development effort in a timely manner[774]. The results are corroborated by previous findings that emphasize the importance of knowledge integration in successful NPD projects[775]. In addition, the model typically specifies how and when different parties should communicate with each other, and helps to ensure that critical front end activities are thoroughly executed and the results are integrated into other development work. For example, customer needs analysis[776] and concept testing[777] have been suggested to be vital in terms of high quality concepts. The front end of innovation is the phase where the coordination of different expertise is critical in order to develop novel, functional and profitable product concepts[778]. In the context of product concept superiority, which is a more short-term and clear outcome target, the

[773] Bisbe and Otley 2004
[774] Ulrich and Eppinger 2003
[775] Eisenhardt and Tabrizi 1995, Dougherty 1992
[776] Bacon et al. 1994, Khurana and Rosenthal 1998
[777] Lees and Wright 2004, Crawford and Di Benedetto 2000
[778] Ulrich and Eppinger 2003

question is more about uncertainty and not equivocality, as it increasingly is in terms of strategic renewal. This uncertainty reduction requires systematic coordination across diverse activities and different parties.

The findings gain support from contingency theory arguments that explain this phenomenon through interdependence and integration needs[779]. The novel development problems create the need for efficient information transfer between organizational functions, leading to interdependence between functions. This further necessitates the effective integration of work activities. Process formalization is evidently one of the most efficient integration devices in defining roles, responsibilities, tasks, and information flows, and it has been positively related to the quality and quantity of information flows and the level of information usage in previous studies[780]. Collaboration and communication between the sales and marketing function and the R&D function is critical in the front end, especially when the organizational culture is engineering dominated[781]. The expertise of the sales and marketing function must be available early on in the project to reduce uncertainties related to customer needs, target markets and the overall profitability of developed products, and to avoid costly re-designs later on the process. Previous evidence shows that without efficient communication between the sales and marketing and R&D functions in the front end, uncertainty both in terms of the market and technology remains high and the likelihood of successful end products is lower[782]. In addition, the findings contribute to the discussion linking process formalization with the creation of dynamic capabilities. Process formalization positively influences knowledge articulation and especially knowledge codification, resulting in learning which co-evolves with dynamic capabilities[783].

The fact that a similar, positive moderating effect was not found under technology uncertainty (hypothesis H8b) lends further support to the previous argument. When only technology uncertainty is high (e.g. new technology is applied to a product that is aimed at existing target markets), the R&D function, which typically leads new

[779] Donaldson 2001
[780] Deshpande and Zaltman 1987, John and Martin 1984, Ruekert and Walker 1987
[781] Workman 1993
[782] Moneaert et al. 1995
[783] Zollo and Winter 2002

concept creation, may quite independently develop the project inside without intensive collaboration with any other internal function, such as sales and marketing[784]. The need for integration, coordination and communication with the sales and marketing function is thus lower and the benefits from process formalization minor.

No moderating effect of market uncertainty (hypothesis H9a) or technology uncertainty (hypothesis H9b) was found on the relationship between outcome-based rewarding and product concept superiority. Since the main effect was also non-existing, the findings call for more empirical research in order to clarify the role of outcome-based rewarding in the front end of innovation. One plausible explanation to consider is the fact that from the investigated management control mechanisms, outcome-based rewarding was used significantly less than average. This may indicate that product concepts are difficult to use as a basis for rewarding and that rewarding occurs in later stages of the innovation process.

The results indicate that under high technology uncertainty, there is a more negative association between front end process formalization and strategic renewal (hypothesis H8d, this was only marginally supported and thus needs to be interpreted with caution). Differences in the time dimension and level of equivocality in used performance measures provide a possible explanation for the results. The possible positive influence of process formalization on coordinated uncertainty reduction may be evened out by the need of free exploration due to high equivocality. Front end projects aiming for strategic renewal consist of long-term future aspirations with a great deal of equivocality[785], i.e. a lack of clarity on which issues are relevant to the innovation task. This may concern e.g. the inability of knowing all possible alternatives in a given choice situation or environmental conditions that should be considered in decision making[786]. Previous arguments state that a formal process or other impersonal mechanisms are not effective in equivocality reduction[787]. In turn, the front end phase itself includes a considerable amount of uncertainty, calling for information processing. Front end projects under high technology uncertainty are

[784] Smith and Reinertsen 1998
[785] Daft and Lengel 1986
[786] Conrath 1967
[787] Daft and Lengel 1986, Conrath 1967

long-term technology development endeavors that need a lot of free-wheeling in order to find the right direction and solid decision criteria[788], and to cope with equivocality. They need a more trial-and-error attitude, adaptation capability and exploration of different alternatives where technological solutions are developed iteratively in small steps, rather than formalized and planned processes[789]. Previous research suggests using project autonomy to promote learning[790]. The results are in accordance with previous suggestions calling for flexibility for projects in the context of high technology uncertainty in order to achieve high performance[791]. They are also supported by previous results showing that flexibility contributes to goal achievement under high project multiplicity due to more efficient coping with complexity and ambiguity[792]. Indeed, the other plausible explanation is that project equivocality also includes high complexity when multiple alternatives and interrelationships need to be considered, which is further found to require more autonomy[793].

It is furthermore likely that in the very front end of innovation, uncertainty is purposefully sought to identify new opportunities, and collaboration across units is exploratory and difficult to frame in process models. In addition, process formalization may lead to overemphasizing market information processing, which can then lead to incrementalism[794] when market studies and concept tests of innovative concepts show poor figures. If formal processes are in use, they may not fit the uncertain context well and, therefore, perform poorly. The results are in line with findings from recent discontinuous innovation studies that recommend separating high uncertainty projects from normal development, using the probe and learn strategy[795] and relying on emergent and fuzzy operating patterns[796]. Previous evidence suggests that the ability to make radical shifts and transform markets requires independent

[788] Moneart et al. 1995
[789] Stringer 2000
[790] Scarbrough et al. 2004
[791] Shenhar 1998
[792] McComb et al. 2007
[793] Larson and Gobeli 1988
[794] Bennet and Cooper 1981
[795] Lynn et al. 1996
[796] Phillips et al. 2006, Simon et al. 2003

units[797] and existing organizational structures can seriously hinder strategic renewal thus creating the need for an ambidextrous organization[798].

The results indicated that under high technology uncertainty, there is a more negative association between outcome-based rewarding and strategic renewal (hypothesis H9d). This partly supports existing understanding that outcome-based rewarding may have harmful effects on the quality of products in the NPD context[799]. An explanation for the counterproductive effect in the context of high technology uncertainty on performance can be sought from the risk-taking attitude[800]. Importance of the entrepreneurial and risk-taking mindset in developing new products is widely acknowledged[801], but tying rewarding to the achievement of outcomes under high technology uncertainty may lead to front end group members making choices and decisions that are based more on proven technological solutions containing less risk and thus inhibiting strategic renewal. Earlier findings indicate that the extent to which a company is willing to take risks is positively associated with the transformation of its competences and markets, which further contributes to radical product innovations[802]. As explained earlier, previous research as well as the results of this study, emphasizes the importance of the intrinsic attractiveness of the task at hand in the NPD context[803]. Moreover, earlier findings suggest outcome-based rewarding (also front end process formalization) may be perceived as a strict external control emphasizing the external motivation sources and decreasing intrinsic task motivation[804], which is a necessity for creativity and strategic renewal. In addition, outcome based rewarding at a group level may lead to sub-optimization from the point of view of the organization if the decomposition of the organizational task is not done carefully[805].

The other possible explanation is that market information and technology information are dissimilar in terms of uncertainty (lack of information)[806]. Market information is

[797] Herrmann et al. 2007, Stinger 2000, Rice et al. 2000
[798] Tushman and O'Reilly 1996
[799] Sarin and Mahajan 2001
[800] Snell 1992
[801] See e.g. Kleinschmidt et al. 2007
[802] Herrmann et al. 2007
[803] Osterloh and Frey 2000
[804] Deci and Ryan 1985
[805] Dosi et al. 2003
[806] Poskela and Martinsuo 2009

intangible and often based on speculation in the case of strategic renewal. A company's current customers can provide misleading information because they are fixed on existing products and their capabilities[807] and the company can fall into customer-led business[808]. Technology information, in turn, is typically more fact based and grounded on verified information that is collected from several research reports and lab studies. Whereas outcome-based rewarding leads to risk-averse behavior under high technology uncertainty, it might cause risk-favorable behavior under high market uncertainty when the front end group tries proactively influence market demand and key customers in order to achieve targets. As previous argumentation suggests, in the case of radical innovations, markets cannot be evaluated with great accuracy since they do not exist; they need to be created[809]. However, it should be noted that the moderating effect of market uncertainty was non-existing. Nevertheless, the difference in market- and technology-related information in terms of uncertainty should be one important aspect for future studies.

The results revealed that the relationship between strategic renewal and front end process formalization and outcome-based rewarding was not moderated by market uncertainty. Market uncertainty was positively associated with strategic renewal, but its moderating effect was non-significant (hypotheses H8c and H9c). From the perspective of management control, the results indicate that the firms included in the survey have been able to develop process and output controls that at least fit their market uncertainty conditions well. The other plausible explanation could be that when pursuing strategic renewal, increased market uncertainty has both positive and negative effects that level out the possible moderating effect, a phenomenon highlighted in some earlier studies also[810].

6.4 Management control in pursuit of product concept superiority and strategic renewal

Management can significantly contribute to both product concept superiority and strategic renewal. The results indicate that management should take a more active role in controlling front end activities, a finding which supports previous general

[807] Christensen and Bower 1996
[808] Slater and Narver 1998
[809] Christensen 1997
[810] Salomo et al. 2007b

suggestions[811]. Since front end process formalization, outcome-based rewarding, strategic vision, informal communication, and participative planning had a non-existing relationship with strategic renewal, but front end process formalization and strategic vision had a positive association with product concept superiority, the results have a significant managerial implication. Management can well use formalized process structures to run their front end projects to pursue strategic renewal if such a control approach is justified by other reasons. For example, companies may want to develop only one formal process in accordance with all the front end projects that will be executed, as previously suggested[812]. The results thus partly conflict with earlier findings that call for more context-specific tailoring of the front end process[813]. The plausible explanation for the conflicting findings could be the type of formalization, for example whether the front end process model is based on a non-linear[814] or linear approach[815].

The results show that management can also share the strategic vision to contribute to superior product concepts without fear of a negative influence on strategic renewal. Management can also use outcome-based rewarding if it is in line with the normal rewarding system without fear of this negatively affecting front end performance. However, as indicated by the findings, outcome-based rewarding has no association with front end performance, thus it is not an effective control mechanism from management's viewpoint. In addition, the results support using informal communication and participative planning. Even though they were not associated directly with front end performance, informal communication had a positive correlation with input control and front end process formalization, and participative planning with front end process formalization, strategic vision and intrinsic task motivation, suggesting a mediating relationship with front end performance. In addition, the results show that management can use input control to contribute strategic renewal without negatively influencing product concept superiority. The results indicate that more research is needed to explain associations other than linear relationships between management control and front end performance, and to clarify

[811] Smith and Reinertsen 1998, McGrath 1996, Wheelwright and Clark 1992
[812] Clausing 1994
[813] Nobelius and Trygg 2002
[814] Koen et al. 2001
[815] Cooper 1998

the role of management control in the form of company-specific control strategies instead of individual control mechanisms.

The results show that front end projects facing very high technology uncertainty in the case of pursuing strategic renewal are a special case requiring management's specific attention. The results indicate that both front end process formalization and outcome-based rewarding are negatively associated with strategic renewal under high technology uncertainty, which suggests separating this kind of development from the rest of the organization. The supports previous findings proposing the use of separate independent units[816] and allowing more freedom in organizing development activities[817] in the case of high uncertainty and the pursuit of radical innovations. The results are also in accordance with previous evidence that stresses the importance of intrinsically motivated people[818] in creative problem solving and pursuing innovative outcomes. Instead of extrinsic outcome-based rewarding, for example, goal-setting[819] and deadlines[820] should be used to challenge an innovation group to pursue strategic renewal in these units.

The results show that if both market uncertainty and technology uncertainty are high, the use of front end process formalization is challenging. Front end process formalization contributes to product concept superiority through enabling better coping with market uncertainty, but it hampers the search for novelty and coping with technology uncertainty and ambiguity, thereby inhibiting strategic renewal. The results suggest that in this case a conscious choice as to which target is more important must be made, a superior product concept or strategic renewal, and the process must be formalized based on this prioritization.

[816] Herrmann et al. 2007, Stinger 2000, Rice et al. 2000, Single and Spurgeon 1996
[817] Phillips et al. 2006, Simon et al. 2003, Stinger 2000, Lynn et al. 1996, Moneart et al. 1995
[818] Osterloh and Frey 2000, Amabile 1998
[819] Parnes 1964
[820] Lindkvist et al. 1998

7 CONCLUSIONS

***"Tomorrow's management processes must nurture innovation in every corner of the organization."* – Gary Hamel**

Appropriate control of organizational activities has been widely researched and there are also a number of studies dealing with management control in the NPD context in general[821]. However, management control studies focusing specifically on the front end of innovation are scarce. The literature review indicated that the separate phases of the innovation process are different in their nature, for example, the front end of innovation is different to the development project phase[822]. In addition, some studies have found that different control mechanisms are applied in these separate phases of the innovation process[823]. In the light of the above findings, the innovation process should not be investigated as a whole without consideration of the specific characteristics of the various process phases. This gap in the existing body of knowledge has been the focus of this dissertation.

This research has provided empirical, context-specific, quantitative findings on management control practices in the front end phase of the innovation process. Seven control mechanisms (input control, front end process formalization, outcome-based rewarding, strategic vision, informal communication, participative planning, and intrinsic task motivation) and their association with front end performance (product concept superiority and strategic renewal) were the main focus of this research. In addition, the moderating effect of market and technology uncertainty on front end process formalization and outcome-based rewarding were investigated.

The first research question for this dissertation was defined as the following: **How are different types of management control mechanisms related to front end performance?** Of the investigated management control mechanisms, front end process formalization, strategic vision and intrinsic task motivation were positively

[821] E.g. Abernethy and Brownell 1997, Nixon 1998, Davila 2000, Hertenstein and Platt 2000, Rockness and Shields 1984, Rockness and Shields 1988, Bonner et al. 2002, Ylinen 2004, Park 1998, Nonaka 1988, Tatikonda and Rosenthal 2000, Brown and Eisenhardt 1997, McGrath 1996, Wheelwright and Clark 1992

[822] Koen et al 2001, Nixon 1998, Zien and Buckler 1997, Rockness and Shields 1984, Kirsch 2004

[823] Kirsch 2004, Choudhury and Sabherwal 2003

related to product concept superiority, reflecting a short-term performance measure. Input control, outcome-based rewarding, informal communication and participative planning were not related to product concept superiority. Input control and intrinsic task motivation were positively related to strategic renewal, reflecting a long-term performance measure. Front end process formalization, outcome-based rewarding, strategic vision, informal communication and participative planning were not related to strategic renewal.

The second research question was defined as: **How do market uncertainty and technology uncertainty influence the relationship between management control mechanisms and front end performance?** The results show that market uncertainty positively moderates the positive relationship between front end process formalization and product concept superiority, i.e. the more market uncertainty, the more positive the relationship. Technology uncertainty does not have moderating effect at all on the relationship between front end process formalization and product concept superiority. Market uncertainty and technology uncertainty have no moderating effect on the relationship between outcome-based rewarding and product concept superiority. Technology uncertainty negatively moderates the relationship between front end process formalization and strategic renewal, i.e. under high technology uncertainty, front end process formalization is negatively related to strategic renewal. Technology uncertainty also negatively moderates the relationship between outcome-based rewarding and strategic renewal, i.e. under high technology uncertainty, outcome-based rewarding is negatively related to strategic renewal. No moderating effect of market uncertainty on the relationship between front end process formalization and strategic renewal or between outcome-based rewarding and strategic renewal exited.

7.1 Contribution to the body of knowledge

The results of this research particularly contribute to the literature on the management of front end of innovation and management control. This study contributes to management control literature in general by focusing on management control in the front end of innovation, which is still a barely touched area in this context. Several studies have indicated that the front end phase of the innovation process is the most

problematic and a less understood process phase in the NPD context[824]. Simultaneously, it is the most critical phase from the viewpoint of new product success since the majority of key decisions that influence the final form and context of anew product are made in this early phase before a NPD project is officially launched[825]. The findings of this study add to the body of knowledge of front end management literature by showing how management can effectively control these critical early development activities and thus contribute to front end performance.

The effectiveness of management control depends on how performance in the front end is measured as individual management control mechanisms are differently associated with performance measures. Two distinct performance measures were used in this study, product concept superiority (a short-term measure) and strategic renewal (a long-term measure). These measures provided a benchmark for studying the effectiveness or contribution of different factors to front end performance.

This dissertation has shown how certain management control mechanisms are associated with front end performance. Quantitative management control studies focusing on the front end phase and aiming to verify theory-based hypotheses are scarce since most studies have been based on qualitative data[826]. Several verified hypotheses are provided in this study. Front end process formalization and strategic vision were found to be associated with superior product concepts. Empirical findings are in conflict with the current body of knowledge on management control, arguing that non-routine and interdependent tasks with high task uncertainty even chaos, issues that characterize the front end of innovation, are not suitable for instituting process control or process formalization[827]. However, the findings of this study support arguments found in product development text books[828] and front end articles[829] that state that formal front end processes lead to improved decision-making and new product success. The results show that front end formalization leads to a

[824] Reid and de Brentani 2004, Herstatt et al. 2004, Nobelius and Trygg 2002, Kim and Wilemon 2002, Cagan and Vogel 2002, Zhang and Doll 2001, Koen et al. 2001
[825] Bonner et al. 2002, Smith and Reinertsen 1998, Wheelwright and Clark 1992
[826] E.g. Kirsch 2004, Choudhury and Sabherwal 2003
[827] Ouchi 1977, Ouchi 1979, Eisenhardt 1985, Burns and Stalker 1961, Donaldson 2001, Lawrence and Lorsch 1967
[828] Cooper 1998, Wheelwright and Clark 1992
[829] Koen et al. 2001, Montoya-Weiss and O'Driscoll 2000, Khurana and Rosenthal 1998

superior concept, but they do not specifically explain how the front end should be formalized, e.g. what kind of process model should be used, even though some landmarks have been provided. This is a venue for future studies. Second, the results show the importance of the strategic vision on superior product concepts. These results are in line with the general understanding of studies dealing with the influence of strategic vision[830]. However, this study provides a novel perspective that the front end phase, where the strategic vision is typically partly challenged, formed and reshaped, benefits from using strategic vision as a control mechanism even though the task may not be straightforward. Thus the vision can and should be formed even though it is likely to change in the course of the conceptualization work.

Empirical findings complemented the prevailing understanding of goal-setting theory which associates setting specific and challenging goals with higher performance in a routine task environment[831]. The results indicated that front end projects, characterized by non-routine work activities, also benefit from management-initiated goal-setting, and were associated with better strategic renewal. In addition, the results indicated that a specific task definition, which is widely acknowledged as being the best practice in initiating a NPD project phase[832], helps to achieve results that have the potential of renewing a company's strategic goals. Finally, by complementing a set of input control mechanisms, the results show the value of allocating appropriate human resources to a particular task. This supports the earlier findings of management control studies[833] and highlights the importance of management's role in achieving strategic renewal. An interesting path for future studies could be to investigate the linkage between the personality traits of front end group members and their influence on front end performance. As discussed as a potential explanation for the results, there are some indications that natural tendencies, besides the learned skills, may have more a important role in success than generally understood since those people with a strong tendency for intuitive and logical thinking may have superior capacity to run front end projects[834].

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[830] Marginson 2002, Englund and Graham 1999, McGrath 1996, Wheelwright and Clark 1992, Kotter 1990
[831] Locke 1968, Locke and Latham 1990, Campbell and Furrer 1995
[832] Wheelwright and Clark 1992, Smith and Reinertsen 1998, Schilling and Hill 1998, Ulrich and Eppinger 2003
[833] Snell 1992, Merchant 1985, Anthony 1988
[834] Stevens and Burley 2003

Further, the findings indicate that the intrinsic task motivation of front end group members is important. High task motivation contributes to both superior product concepts and strategic renewal. The results contribute to empowerment and self-control theories that explain how intrinsic task motivation emerges[835], and emphasize management's role in the intrinsic task motivation of employees besides using more traditional control mechanisms. As explained previously, management does not have direct access to improve intrinsic task motivation, but appropriate settings and conditions can be put into place for intrinsic motivation to emerge, e.g. by allowing and emphasizing self-control mechanisms.

The majority of the theory-based hypotheses did not get empirical support. This questions some of the prevailing assumptions of management control. For example, previous findings stress the importance of informal control mechanisms in the front end[836]. Yet the results indicated that informal communication between management and front end groups does not contribute to performance, but instead should be used merely to complement formal control mechanisms. Furthermore, employee involvement and participation are emphasized in many control studies[837]. The empirical findings indicated that participative planning is not associated with front end performance. The results support earlier findings that employees are capable of assisting in defining operative goals but not strategic goals[838]. Simultaneously, the results also challenge the theoretical management control framework used in this study[839]. It can be questioned whether the level of formality or level of interactivity should be treated as distinct dimensions of management control or as integral parts of e.g. input or process control dimensions.

This thesis also makes a contribution to contingency theory by testing market uncertainty and technology uncertainty as moderating variables between management control mechanisms and front end performance[840]. The results indicate that the influence of uncertainty is very different depending on whether it stems from the

[835] Manz 1986, Thomas and Velthouse 1990, Luthans and Davis 1979
[836] E.g. Kirsch 2004
[837] Fang et al. 2005, Ramaswami 1996, Schilling and Hill 1998, Sagie 1996, Smith and Reinertsen 1998
[838] Bonner et al. 2002
[839] Hales 1993
[840] Burns and Stalker 1961, Thompson 1967, Lawrence and Lorch 1967, Perrow 1967, Galbraith 1973, Chandler 1972

market or from technology, thus complementing the body of knowledge of NPD literature in terms of understanding the influence of uncertainty[841]. It was especially noticed that market uncertainty strongly moderated the relationship between front end process formalization and product concept superiority, whereas a similar moderating influence was non-existing in terms of technology uncertainty. This was explained to be mainly caused by the improved coordination capability between different functions under high market uncertainty. Furthermore, high technological uncertainty may have a detrimental effect on strategic renewal if outcome-based rewarding is applied due to the different nature of risk-taking behavior under market uncertainty and technology uncertainty. Market-related information and technology-related information could be dissimilar in terms of uncertainty (lack of information) therefore triggering different response actions.

In addition, the results verify that management should indeed be actively involved in the front end projects in their early stages[842], and thereby are evidence of the importance of the front end of innovation to a firm's dynamic capabilities[843]. Management can and should manage and redeploy the company's resources in response to the changing business environment while pursuing new product innovations to achieve strategic renewal in the front end of innovation.

The critical question is that if the front end of innovation is different to the development project phase, how does that influence the applicability of different management control mechanisms? In the light of the empirical findings, the front end of innovation can be controlled with similar mechanisms as a development project. The broadened concept of project[844] to encompass also pre-project, i.e. front end, activities is relevant in terms of management control. For example, the formal model should be applied both in the execution of development projects and execution front end projects. In addition, management's emphasis on defining strategic goals and allocating appropriate resources contributes to success in both cases. However, even though the similar mechanisms can and should be applied, they probably should be

[841] Garcia and Calantone 2002, Tidd et al. 2001, Lynn and Akgun 1998, Danneels and Kleinschmidt 2001, Yap and Souder 1994
[842] Smith and Reinertsen 1998, McGrath 1996, Wheelwright and Clark 1992
[843] Teece et al. 1997, Eisenhardt and Martin 2000, Salomo et al. 2007, Verona and Ravasi 2003
[844] See e.g. Artto et al. 2006

applied in different manners considering the varying nature of these separate phases[845]. For example, though the strict and mechanistic stage-gate approach[846] works well in the development project phase, non-linear and more flexible process models[847] are suitable for front end projects.

Finally, the results contribute to the emerging theoretical discussion of project strategies[848], indicating that front end projects may have dissimilar strategic goals and can thus be evaluated with different performance measures, which can further be considerably influenced by using different management control mechanisms.

7.2 Managerial implications

This dissertation provides a thorough review of management control modes and management control mechanisms that can be used in the front end of innovation (see Chapter 2.1). This review may broaden management's current understanding of different control mechanisms and their applicability in different organizational contexts. Moreover, the empirical results of this dissertation help management to define appropriate management control for the front end of innovation. The empirical findings reveal how certain control mechanisms are associated with front end performance and how market uncertainty or technology uncertainty moderate this relationship. The managerial implications can be summarized as following.

When the goal is short-term-oriented to pursue superior product concepts:

- First, managers are advised to define a systematic and formal process for the front end. This includes a definition of the reporting system, decision-making structure and a process model including work activities. However, be aware that not all process models are alike, and tailor a process model that is suitable to the context of the organization. In addition, management is advised to make sure that front end projects are really conducted in accordance with the defined procedures. The potential decrease in individual creativity caused by the formalization is well compensated for by improved innovativeness, i.e. the ability to put the created ideas into practice in the organization. In the case of

[845] Koen et al 2001, Nixon 1998, Zien and Buckler 1997, Rockness and Shields 1984, Kirsch 2004
[846] E.g. Cooper, 1998
[847] E.g. Koen et al. 2001
[848] Artto et al. 2008, Artto et al. 2008b

high market uncertainty, a formal approach is important. The positive influence on performance especially derives from the improved capability of coordinating diverse activities conducted in different parts of the organization (e.g. in the R&D function, sales and marketing function). Informal communication should be used to complement the control influence of process formalization; the use of only informal communication for control purposes is not adequate. See Chapter 6.1.2 for a more detailed discussion.

- Second, managers should build and share a compelling strategic vision that is well understood and internalized among employees. This brings the necessary consensus, aligns diverse activities and helps to achieve a critical mass of effort to enable better product concepts. See Chapter 6.1.2 for a more detailed discussion.
- Third, managers are advised to take care of the internal task motivation of front end group members. Task motivation cannot be given, but management should create an environment from which internal task motivation emerges. Motivated employees are capable of exerting self-control in work tasks, i.e. taking more responsibility for the direction of work activities and the ways in which the work is carried out. Motivated front end group members are the source of superior product concepts. See Chapter 6.1.2 for a more detailed discussion.

When the goal is long-term-oriented to pursue strategic renewal:

- First, managers are advised to put special emphasis on human resource allocation considerations in front end projects aiming at strategic renewal. These kinds of front end initiatives are the most challenging and require special skills from front end group leaders and group members. Management should make sure that the front end group is cross-functional and has the necessary expertise and competence for the given task. The leader of the front end group has a critical role in terms of front end performance. Capability through natural tendencies and acquired skills for creative thinking and reshaping and branching ideas in order to find the right direction for front end efforts is important. See Chapter 6.2.2 for a more detailed discussion.

- Second, managers are advised to put an emphasis on task definition and the definition of strategic goals for front end projects. It is management's job to frame the task for front end groups in order to focus development efforts. Moreover, managers are advised to set challenging strategic goals for front end projects. Through task definition and strategic goal-setting, management provides a common direction and challenging targets for development activities while decisions on more operative-level matters can be left up to the front end group. This is not an easy task from management's point of view, but still the time devoted to this activity is well compensated for by improved front end performance. See Chapter 6.2.2 for a more detailed discussion.
- Third, again the internal task motivation of front end group members is even more important in front end projects aiming at strategic renewal. This is due to the more challenging execution and transformation of embryonic ideas into product concepts. Obstacles and even organizational resistance against new product ideas requires highly motivated front end group members to create successful end results. Managers are advised to develop new means and to remove obstacles to motivate front end group members. See Chapter 6.2.2 for a more detailed discussion.
- Fourth, in the case of high technology uncertainty, two control mechanisms have a negative influence on strategic renewal. One is front end process formalization. In the case of high technology uncertainty (e.g. front end projects applying totally new technology), practitioners are advised to loosen formalized processes and allow more freedom or even a different approach on how activities are carried out. The second mechanism is outcome-based rewarding. Tying rewarding only to the outcome achieved in the case of high technology uncertainty, leads to 'playing it safe' and the selection of more reliable, less risky alternatives, thus decreasing the potential for strategic renewal. See Chapter 6.3 for a more detailed discussion.

Many companies apply a similar defined approach to the front end of innovation regardless of the targets (short-term or long-term performance) set for the front end projects. In general, management is advised to take a more active role in controlling the front end of innovation since none of the investigated control mechanisms had a

negative influence on performance in any situation with one exception, i.e. front end process formalization and outcome-based rewarding in the case of high technology uncertainty when strategic renewal was pursued. Management can well focus on controlling inputs, using formalized process structures to run front end projects, challenging employees with a compelling strategic vision, and nourishing the intrinsic task motivation of front end groups, since these factors contribute to front end performance. Management can use participative planning and trust in informal communication without fear of this negatively influencing performance. Management can also use outcome-based rewarding if it is in line with the normal rewarding system without hampering front end performance. Long-term, front end projects aiming at strategic renewal and including high technology uncertainty are a special case that requires management's attention and sensitivity to tailor a less formal front end process and rewarding system which supports risk taking and long-term aspirations.

The situation where both market uncertainty and technology uncertainty are high is challenging from the viewpoint of front end process formalization. Front end process formalization enables a decrease in market uncertainty through the improvement of coordination, but it could prevent free-wheeling and hinder the development of risky technological choices, lowering the potential for strategic renewal. In this case, management could make a conscious decision on which type of performance, a short-term-oriented and clearly defined superior product concept or more long-term and future-oriented strategic renewal, is more appropriate to pursue and adjust the process characteristics accordingly.

7.3 Limitations of study

This study covered only part of the management control mechanisms that are typically used in the front end of innovation. A conscious choice was made of which mechanisms to include and which not to in order to achieve a manageable research scope. Clan control, setting of concept limitations, value control and management intervention are examples of management control mechanisms that were not covered by this study. In addition, some other control variables (e.g. stability of the business

environment or product (concept) modularity[849]) and contingency factors (e.g. complexity of the development task or company size) could have been used. These are limitations that should be taken into account when interpreting the findings and when designing further studies.

Evidently, this study has certain success bias since the example front end projects were all completed. In real life many of front end ideas are stopped in the middle when it is realized that the idea does not have the adequate preconditions to succeed. In addition, those selected front end projects that were used as examples were probably more successful than average. Even though respondents were asked to select the last completed front end project, people have a tendency to select the project which is more successful if several options are available[850].

This study trusted the responses of a single informant in each front end project. As stated earlier, the question of whether or not to use a single informant is widely debated in the literature[851]. However, the decision to trust the judgment of a single respondent was consciously made and special emphasis was put on selecting the a knowledgeable informant in the matter of subject. Actually, it could be argued that there is no other person in the investigated companies who could have given more reliable information on a particular front end project than the person who is responsible for controlling these projects. Thus, it could be speculated whether the reliability of the results would have increased if more than one informant had been used. However, since the use of several informants typically increases the reliability of results, this could be one way of achieving more reliable results in future studies focusing on management control in the front end of innovation. In this case, one informant could focus on evaluating the performance of the front end project and another could judge the intensity of the used control mechanisms.

It can be always speculated how well respondents were able to make a distinction between the used control mechanisms in the front end phase and in the development project phase, even though respondents were requested to focus only on those

[849] Tiwana 2008
[850] Herstatt et al. 2004
[851] Campbell 1955, John and Reve 1982, Phillips 1981

mechanisms used in the front end of innovation. Since the study relies on retrospective data, this question is relevant and should be remembered when considering the limitations of this study.

A conscious choice was made to investigate management control from the management's point of view in this study. Obviously, this gives a one-sided view on management control and front end performance. A more complete view could be obtained by investigating management control from the point of view of the persons under control, i.e. to focus on the viewpoint of the front end group leaders. In addition, front end performance evaluated e.g. a from customer's perspective would give more insight into the influence of different control mechanisms.

The variance explained by independent management control measurement constructs and dependent front end performance measurement constructs was only on a mediocre level, lowering the level of validity of the measurement models. In practice, this means that the created measurement constructs were not complete, but there are several other factors that are needed to explain the higher proportion of variance. This challenge was partly realized when designing the measurement instruments, but accepted in order to obtain a manageable research scope. However, future studies should formulate broader measurement constructs for both management control constructs and performance constructs to have more valid measurement instruments. In addition, the total variance explained in both measurement models could have been higher to understand management's role in front end performance. In practice, this means that besides management's task of controlling front end projects, there are also other important factors that influence front end performance such as the excellence of the original identified opportunity or the capability level of the front end group. Future studies should control of these and other possible relevant factors.

Some measurement construct modifications from the predefined measurement model were made in this study in order to remove variables causing overlapping measurement constructs or to improve the reliability of the constructs. The strategic vision was originally designed to consist of variables based on value control. It was assumed that the strategic vision, the influence of organizational values, and the degree to which there was consensus of organizational values among front end group

members would have formed a value control measurement construct. However, inclusion of these two additional measurement items caused an unclear factor solution and they were thus removed from the final factor model. In addition, outcome-based rewarding was originally designed to include four items. The excluded measurement item concerned group-based non-monetary rewarding, which did fit the factor model well but considerably decreased the reliability of the measurement construct. Exclusion of this item enabled a measurement construct with good reliability.

The validity of the used measurement constructs was appropriate as discussed in detail in Chapter 4.5.2. Several techniques were used to ensure the validity of the measurement constructs. For example, the definition of measurement constructs was based on extensive literature analysis, earlier verified measurement items were used whenever possible, measurement constructs were pre-tested, multi-item measurement constructs were used, and explorative factor analysis was used to investigate validity post-hoc. Overall, these activities led to good face, content, criterion and construct validity of the measurement constructs. However, as discussed in Chapter 4.5.2, convergent validity in the measurement constructs front end process formalization, market uncertainty, and superiority of product concept was not perfect. Future studies could focus on improving the convergent validity of these constructs. Low convergent validity may indicate that the factor solution is not uniform but may include more than one single factor. For example, in the light of the analysis the front end process formalization measurement construct may have two different factors, one which concerns the execution of the front end in accordance with the defined process and one which regards other types of formalization such as reporting structures and the existence of decision gates. In addition, discriminant validity between front end process formalization and the influence of strategic vision was something that could be improved in future studies. Low discriminant validity in these cases may indicate that the execution of front end projects in accordance with the defined process and strategic vision are somehow interrelated and explained by other factors not used in this study.

The strong correlation between the dependent variable strategic renewal and the control variables/moderator variables market uncertainty and technology uncertainty may indicate low discriminant validity between these constructs. It makes sense that

strategic renewal requires entering new markets, acquiring new customers and applying new technologies. However, future research should investigate these constructs in detail and carefully consider how to measure these variables to ensure high discriminant validity.

The reliability of the measurement constructs used was discussed in depth in Chapter 4.5.1. The reliability of product concept superiority was below the general threshold value .70. Low reliability is problematic since it may lead to underestimating the relationships between constructs[852]. Since the actual reliability was .69, just below the target, this does not appear to be a serious threat for reliable measurement of front end performance. However, future studies could specifically focus on developing more reliable measures for investigating product concept superiority. In addition, strategic vision was measured by using only a single measurement item, and thus the reliability cannot be evaluated. Even though four of the seven independent variables consisted only of three different measurement items, the reliability of these constructs well exceeded the threshold value and can be considered adequate and good for this study.

The non-response analysis indicated that the sample was representative of the population, i.e. medium and large-sizes companies with product development activities in Finland. However, it can be speculated that non-respondent firms may have been firms that have not considered nor developed a systematic approach to handle the front end of innovation. It could also be that these firms do not consider the front end as an important phase of the innovation process, but are instead more concerned about the efficiency of the execution of NPD projects. These factors could have decreased the companies' motivation to participate in the study and thus the final sample might be biased toward companies that have above-average practices in the front end.

The study may have some limitations concerning the generalizability of the results. First, the results concern only physical product innovations, and other innovation types, such as service innovations, were not in the scope of this study. It is likely that service innovations that typically require continuous interaction between the

[852] Nunnally 1978

development organization and customer require different types of management control. In addition, small companies were excluded in the sample and thus the results cannot be generalized for them. It is likely that small companies do not require formal structures in management control but are able to rely more on informal and flexible control structures. The sample consisted of Finnish companies only. The critical question is whether the results are applicable to other countries as well, which could be studied by using a similar questionnaire in other countries in future research. However, the generalizability of the results is relatively good for companies of Western origin. Finland and other Nordic countries have a tendency toward more equal management systems, i.e. less authoritarian approaches are favored compared to e.g. countries in Central Europe. This may have some minor influences on the applicability of different management control mechanisms.

Since the collected empirical data is cross-sectional, i.e. collected at a particular point in time, it does not allow for testing hypothesized causal relationships directly. Thus all the arguments concerning causal relationships are only theoretically justified. A longitudinal approach would provide more insight into the causality between management control mechanisms and front end performance. This could be one alternative topic in future studies.

7.4 Directions for future research

As this study was one of the first quantitative studies to analyze management control in the front end of innovation, it provides several starting points for future research efforts in this field. Some of the most relevant focal areas for future studies have been mentioned earlier in the study. However, I would like to point out three important alternative areas for future focus: control strategies, the difference between market and technology uncertainty, and longitudinal studies.

First, instead of individual control mechanisms, future studies should investigate possible broader control strategies, i.e. a set of different control mechanisms that management has selected to be used in the front end in order to fit the context of organization. For instance, there was a positive correlation between front end process formalization, input control and informal communication, suggesting the investigating of broader control strategies besides separate mechanisms. Interrelationships between

different control mechanisms in the form of company-specific control strategies and their possible impact on performance outcomes should be investigated to increase understanding of the complex nature of management control in the front end of innovation.

Second, this study indicated that market uncertainty and technology uncertainty each have a different effect on the applicability of control mechanisms in terms of performance. For example, under high market uncertainty front end process formalization is critical for success, whereas under high technology uncertainty its influence on front end performance is the reverse. Since front end projects are to a great extent uncertainty reduction devices, understanding the differences between market and technology uncertainty is critical for effective management control. Future research should be able to shed more light on the influence of market uncertainty and technology uncertainty separately, not uncertainty in general, on the applicability of different management control mechanisms.

Third, to get a more holistic understanding of management control in the NPD context longitudinal studies, i.e. the follow-up of development initiatives during different phases (front end, development project, commercialization) of the innovation process, could be carried out. This would help in understanding how management control should be changed when an idea proceeds along the development funnel.

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APPENDIX A

SUCCESSFULLY MANAGING THE EARLY PHASE OF THE INNOVATION PROCESS?

Dear Respondent,

The Innovation Management Institute (IMI) of Helsinki University of Technology is conducting a large survey on research management practices and work methods of the early phase of the innovation process (= the front end of innovation) in Finnish companies. The study focuses on product development. The sample of the survey consists of all large and medium-sized companies in Finland with product development activities (source: The Blue Book by Helsinki Media). The results of the study will be used by IMI, TEKES and Teknologiateollisuus Ry.

The study tries to identify the management practices and work methods that are critical to the success of the front end of innovation. Furthermore, the study examines the differences in successful management between the development of incremental and radical innovations. The survey is considered to be very important due to its wide scope and topical subject. In order to achieve a comprehensive and truthful view of the subject at hand, every response is important. **The benefits to the respondent include**:

1. By filling out the survey and considering the questions you may get **new concrete ideas** on how to further improve front end management and execution in your company.
2. All respondents will receive **a summary report** of the survey results in spring 2006. The report will focus on the critical success factors in the management and execution of the front end of innovation.
3. The survey is part of the COINNO research project (www.imi.hut.fi/projects/coinno), which focuses specifically on the front end of the innovation process. Respondents are invited to the one-day final seminar (spring 2006) where the results of the three-year project will be presented. **Admission to the seminar is free for respondents.**
4. Respondents will receive **a book** covering the results of the research project. The book will include the most relevant findings, the developed management models and practices, and will give fresh ideas on how to improve the effectiveness of front end innovation in companies.

There are **two** questionnaires, instruction letters and return envelopes enclosed in the envelope. Questionnaire A is targeted at **the director/individual who controls individual front end projects** from the viewpoint of management. Please: 1) complete questionnaire A, and 2) deliver the other questionnaire (Questionnaire B), instruction letter and return envelope to **a selected person who has recently been responsible for managing a front end project** and ask him/her to answer and return the questionnaire. Note! If you do not belong to the target group (the director/individual who controls individual front end projects from the viewpoint of

management), we kindly ask you to **forward the questionnaire onto the right person in your organization**.

Filling out the survey is required for participation in the study. The survey takes about 35 minutes to complete, including reading the instructions and background. All responses will be handled with the utmost confidentiality and responses of individual companies or respondents shall not be presented. Individual answers are reported only as part of a larger sample of companies. You may return the completed survey 1) by sending it back to IMI in the pre-paid return envelope enclosed 2) or by faxing it to Jarno Poskela (fax number: 09-451 3665)

We kindly ask you to return the completed questionnaire by 15.10.2005. If you have further questions, please contact Jarno Poskela (jarno.poskela@hut.fi, 050-3819773).

With kindest regards,

Pekka Berg	Rauli Hulkkonen	Kaj Salminen
Innovation Management Institute	TEKES	Teknologiateollisuus Ry.

APPENDIX B

SURVEY INSTRUCTIONS

Please read the following instructions before completing the questionnaire!

1. The purpose of the survey

The purpose of the survey is to clarify how management control/steer development of new product concepts in the front end of innovation. The term "control" in this context means different practices and mechanisms that are used to ensure that a developed product concept corresponds to the needs and goals of the organization. Management control aims at ensuring both the strategic alignment and strategic renewal of operations according to changes happening in the business environment.

2. Definitions used

The innovation process can be roughly divided into three different phases (Figure 1): an early phase, i.e. **front end phase**, a development project phase, and a commercialization phase. The front end is the phase that precedes the formal and well-structured development project phase. **Only the front end phase is the focus of this study (area inside the dashed line in the figure).**

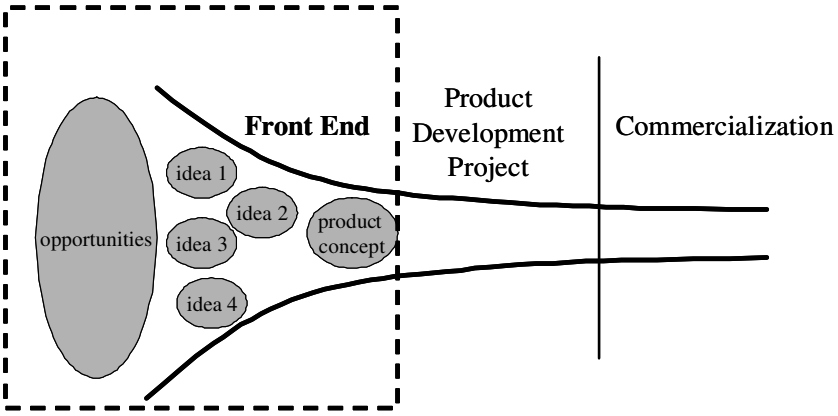

Figure 1. The front end phase of the innovation process.

The front end phase starts when a new product opportunity (= *e.g. unsatisfied customer need or technological invention*) is identified. These opportunities are translated into new product ideas (= *first unrefined solution to an opportunity).* The output of the front end phase is a defined product concept (= *a more defined form of the idea e.g. including features, customer benefits, the used technology and business case).*

3. Questionnaire

In Part Two of the questionnaire, you are requested to select the most recently completed front end project. All questions in Part Two should be answered based on this one example front end project. The selected front end project can be at any stage after the front end, e.g. in the development project phase, it may have been aborted during the development project, or in the commercialization phase. We

ask you to choose in particular the last completed front end project you have personally controlled/steered from the viewpoint of management, regardless of whether you think the front end project was a success or a failure. For this research, both successful and unsuccessful front end projects are equally important.

4. Response choices

Most questions are in the form of statements and closed questions. Choose the answer that best matches the situation in your company or in the front end project.

Please answer all questions as completely and precisely as possible. Since innovation management practices vary from company to company, it may be possible that you encounter questions that do not fit your company. In this case select "N/A" (= Not applicable). You can also explain your choices if you so wish. All additional comments are welcomed.

It takes approximately 35 minutes to take the questionnaire, including reading the cover letter and response instructions.

Thank you for your participation!

APPENDIX C

PART ONE: COMPANY BACKGROUND

Please answer the front end project-related questions either from the whole company or a single business unit viewpoint. A business unit in this context is a division that has its own strategy and profit responsibility. If you are working in a unit like this, please answer the questions from the viewpoint of this unit only. In all other cases, please answer the questions from the perspective of the whole company.

1. **I am answering the questions (choose one only):**
   - ❒ From the viewpoint of a business unit
   - ❒ From the viewpoint of the whole company

Note! The selection you have made will be referred to as the "organization" from this point onwards.

BACKGROUND OF RESPONDENT

2. **The function in which you are working:**
   _____

3. **Your position (title) in the organization:**
   _____

4. **The number of years you have been working in the current position:** _____ years

5. **The number of years you have been working in the current organization:** _____ years

BACKGROUD OF ORGANIZATION

6. **Is there a separate group of people in your organization which is responsible for developing new product concepts?**
   - ❒ Yes
   - ❒ No

7. **In how much detail is a front end process defined in your organization:**
   - ❒ Not defined at all
   - ❒ Defined superficially
   - ❒ Defined in some detail
   - ❒ Defined in great detail
   - ❒ Do not know

8. **Which of the following best describes the structure of your organization (choose one only):**
   - ❒ Line organization
   - ❒ Matrix organization
   - ❒ Project organization
   - ❒ Other, what: _____
   - ❒ Do not know

9. **In which industry does your organization operate?**
   _____

10. **Which of the following best describes the markets in which your organization is operating (choose one only):**
    - ❒ Business-to-consumer (B2C)
    - ❒ Business-to-business (B2B)
    - ❒ Combination of B2C and B2B
    - ❒ Other, what: _____
    - ❒ Do not know

11. **Which of the following best describes the strategy of your organization (choose one only):**
    - ❒ Cost leadership (CL)
    - ❒ Differentiation (D)
    - ❒ Combination of CL and D
    - ❒ Other, what: _____
    - ❒ Do not know

12. **How many front end projects are typically simultaneously under execution in your organization?**
    About _____ projects

13. Please rate the following statements on the business environment of your organization:	Strongly disagree	Some-what disagree	Do not agree or disagree	Some-what agree	Strongly agree	N/A
Our organization has had the same customers for several years already.	❒	❒	❒	❒	❒	❒
We are operating in fast changing markets.	❒	❒	❒	❒	❒	❒
The product technology used in our industry changes rapidly.	❒	❒	❒	❒	❒	❒
The majority of new product ideas are based on new technological inventions in our industry.	❒	❒	❒	❒	❒	❒
Competition is fierce in our industry.	❒	❒	❒	❒	❒	❒
The market shares of competing companies are stable in our industry.	❒	❒	❒	❒	❒	❒

PART TWO: THE FRONT END PROJECT

Please choose the most recent front end project as an example case and answer the questions on how management controlled/steered the front end project based on this particular case. Management control in this context means the different practices and mechanisms that are used to ensure that a developed product concept corresponds to the needs and goals of the organization. Management control aims at ensuring both the strategic alignment and strategic renewal of operations according to changes occurring in the business environment.

14. The example front end project was started in: _____

15. The example front end project was finished in: _____

16. Which of the following best describes the starting point of the front end project:

❒ The project was started in reaction to an external market threat
❒ The project was started to create proactive competitive advantage for the organization

17. Which of the following best describes the goal of the front end project:

❒ The goal of the front end project was to improve long-term profitability
❒ The goal of the front end project was to improve short-term cash flow

18. Please answer the following questions on the planning of the front end project: To what extent did management…	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
…define the task for the development group?	❒	❒	❒	❒	❒	❒
…consider who would be the appropriate person for managing the front end?	❒	❒	❒	❒	❒	❒
…consider who would be the appropriate persons as front end group members?	❒	❒	❒	❒	❒	❒
…emphasize the strategic importance of the product opportunity while allocating financial resources to the front end project?	❒	❒	❒	❒	❒	❒
…define the strategic objectives for the front end work?	❒	❒	❒	❒	❒	❒
…define operative targets for the front end group?	❒	❒	❒	❒	❒	❒
…define a cost budget for the front end project?	❒	❒	❒	❒	❒	❒
…define a schedule for the front end project?	❒	❒	❒	❒	❒	❒

19. Please answer the following questions on the planning of the front end project: To what extent…	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
…was task definition based on informal discussions between management and the front end group?	❒	❒	❒	❒	❒	❒
…were strategic goals of the task informally discussed between management and the front end group before the task was started?	❒	❒	❒	❒	❒	❒
…did the front end project include previews in which plans related to different activities were discussed with management?	❒	❒	❒	❒	❒	❒

20. Please answer the following questions on the selection and reporting practices of the front end project: To what extent…	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
…was the evaluation of new product ideas based on the use of strategy-based selection criteria?	❒	❒	❒	❒	❒	❒
...was the selection of the final product concept based on the use of strategy-based evaluation criteria?	❒	❒	❒	❒	❒	❒
…was a reporting system targeted towards management used?	❒	❒	❒	❒	❒	❒
…was management reported of the exceptions related to the planned execution of the front end project?	❒	❒	❒	❒	❒	❒

21. Please answer the following questions on front end practices: To what extent…	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
…was the front end project executed according to the defined process model?	❒	❒	❒	❒	❒	❒
…was the front end project executed according to the instructions defined for the front end phase?	❒	❒	❒	❒	❒	❒
…were official document templates used during the front end project?	❒	❒	❒	❒	❒	❒
…did the front end project include decision points/gates where the project was evaluated from a strategic point of view?	❒	❒	❒	❒	❒	❒
…were check lists covering strategic questions used during the front end project?	❒	❒	❒	❒	❒	❒
…did management supervise that the front end group followed the defined procedures?	❒	❒	❒	❒	❒	❒
…did a steering group guide the front end project?	❒	❒	❒	❒	❒	❒

22. Please answer the following questions on co-operation between the front end group and management: To what extent…	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
…did management change the original strategic goals during the front end project?	❒	❒	❒	❒	❒	❒
…did management participate in the internal decision making of the front end group?	❒	❒	❒	❒	❒	❒
…did the front end project have a committed supporter from management who helped the project proceed?	❒	❒	❒	❒	❒	❒

23. Please answer the following questions on co-operation between the front end group and management: To what extent, did the front end group…	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
…have formal conversations with management where the front end project was evaluated from the strategic viewpoint?	❒	❒	❒	❒	❒	❒
…have responsibility for defining strategic objectives for the front end project within the limits of the organization's strategy?	❒	❒	❒	❒	❒	❒
…participate in defining strategic objectives for the front end project?	❒	❒	❒	❒	❒	❒
…have the ability to make changes to the strategic goals set for the front end project in the case that new important information emerged?	❒	❒	❒	❒	❒	❒
…participate in defining formal control mechanisms for the front end project?	❒	❒	❒	❒	❒	❒
…take responsibility for achieving the goals set for the front end group?	❒	❒	❒	❒	❒	❒

24. Please rate the following statements on the activities of management and the front end group:	Strongly disagree	Some-what disagree	Do not agree or disagree	Some-what agree	Strongly agree	N/A
The strategic vision guided the decision making of the front end group.	❒	❒	❒	❒	❒	❒
The organization's values guided the decision making of the front end group.	❒	❒	❒	❒	❒	❒
Management motivated the front end group.	❒	❒	❒	❒	❒	❒
Management supported the work of the front end group.	❒	❒	❒	❒	❒	❒
There was a common understanding of the organization's values among the front end group.	❒	❒	❒	❒	❒	❒
Members of the front end group took full responsibility for goal achievement set for the front end project.	❒	❒	❒	❒	❒	❒
Members of the front end group did more than their share (exceeded expectations).	❒	❒	❒	❒	❒	❒
Members of the front end group were proud of the results achieved in the front end project.	❒	❒	❒	❒	❒	❒
Members of the front end group had a free hand to choose the appropriate means to pursue goals set for the front end project.	❒	❒	❒	❒	❒	❒
Members of the front end group were familiar with the work content and work practices of each other.	❒	❒	❒	❒	❒	❒
Members of the front end group were able to evaluate the end result and success of the work done by other group members.	❒	❒	❒	❒	❒	❒
There was intensive collaboration in the front end group during the front end project.	❒	❒	❒	❒	❒	❒
There was intensive discussion about the work content between the front end group and other organizations during the front end project.	❒	❒	❒	❒	❒	❒

25. Please rate the following statement on the front end phase:	Strongly disagree	Some-what disagree	Do not agree or disagree	Some-what agree	Strongly agree	N/A
There was a healthy rivalry during the front end project and only the best ideas were included in the product concept.	❒	❒	❒	❒	❒	❒

26. How many internally competing front end groups developed a solution to the same product opportunity/problem?

- ❒ 0
- ❒ 1
- ❒ 2
- ❒ More than 2
- ❒ Do not know

27. Please answer the following questions on the decision making of the front end group and actions taken by management: To what extent…	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
…were the organization's strategic plans steered toward the decision making of the front end group?	❒	❒	❒	❒	❒	❒
…did the organization's strategic plans set restrictions on the decision making of the front end group?	❒	❒	❒	❒	❒	❒
…did management set limitations (e.g. related to quality or target costs) on the developed product concept?	❒	❒	❒	❒	❒	❒
…did the front end group informally communicate (e.g. hallway chats) with management?	❒	❒	❒	❒	❒	❒
…did the front end group informally exchange information (e.g. e-mail) with management?	❒	❒	❒	❒	❒	❒
…did the front end group have informal meetings with management during the front end?	❒	❒	❒	❒	❒	❒
…did management follow the front end project by regularly visiting the front end group?	❒	❒	❒	❒	❒	❒
…was there "a mentor" in the front end project from management who controlled the work of the front end group?	❒	❒	❒	❒	❒	❒

28. Please answer the following questions on the rewarding of the front end group: To what extent was the compensation of front end group members…	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
…based on the objective evaluation of the achievement of defined goals?	❒	❒	❒	❒	❒	❒
…based on management's subjective evaluation of the achievement of defined goals?	❒	❒	❒	❒	❒	❒
…monetary compensation based on the achievement of defined objectives?	❒	❒	❒	❒	❒	❒
…non-monetary recognition based on the achievement of defined objectives?	❒	❒	❒	❒	❒	❒
…personal compensation based on individual accomplishment?	❒	❒	❒	❒	❒	❒

29. The above statements describe different potential control/steering mechanisms in the front end phase. If the front end project was controlled in other important ways by management, please describe those ways:

_____

_____

_____

_____

_____

30. Please rate the following statements on the target markets and used technologies of the product concept:	Strongly disagree	Some-what disagree	Do not agree or disagree	Some-what agree	Strongly agree	N/A
The planned target markets for the product concept were new to our organization.	❒	❒	❒	❒	❒	❒
The planned target markets for the product concept were also new to other companies in the industry of our organization.	❒	❒	❒	❒	❒	❒
Our organization's existing market research capabilities were not adequate for the gathering of market information needed for the product concept.	❒	❒	❒	❒	❒	❒
The market research/gathering of market information was done by using new methods that were not previ-ously used in our organization.	❒	❒	❒	❒	❒	❒
The applied technology in the product concept was new to our organization.	❒	❒	❒	❒	❒	❒
The applied technology in the product concept was also new to other companies in the industry of our organization.	❒	❒	❒	❒	❒	❒
Our organization's existing R&D capabilities were not adequate for developing the product concept.	❒	❒	❒	❒	❒	❒
Technology development and technology verification of the product concept was done using new methods that were not previously used in our organization.	❒	❒	❒	❒	❒	❒

31. Please answer the following questions on the transparency of the front end project: To what extent…	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
…did management know the front end activities that the front end group did in defining a product concept?	❒	❒	❒	❒	❒	❒
…did management know what kind of end result was expected from the front end project based on the task definition, goal setting and resource allocation?	❒	❒	❒	❒	❒	❒
…was it possible to objectively measure the end result of the front end project?	❒	❒	❒	❒	❒	❒

32. To what extent did a design change of one component influence/would have influenced other components of the product?	Not at all	To a little extent	To some extent	To a great extent	To a very great extent	N/A
	❒	❒	❒	❒	❒	❒

33. Which of the following best describes the developed product concept (choose one only):

- ❒ A minor component in a product to be sold to customers
- ❒ A major component in a product to be sold to customers
- ❒ A stand-alone product to be sold to customers
- ❒ Do not know

34. How many people were working in the front end group on average? About _____ people

35. How many competence areas (functions or departments) including internal and external parties were involved in the front end project? About _____ competence areas

36. How many <u>new</u> components were included in the product described by the product concept?

- ❒ 0-4
- ❒ 5-9
- ❒ 10-14
- ❒ 15 or more
- ❒ Do not know

37. Please evaluate the complexity of the product described in the product concept:

- ❒ Very simple
- ❒ Quite simple
- ❒ Quite complex
- ❒ Very complex
- ❒ Do not know

38. Based on your current information, rate the following statements on front end success:	Strongly disagree	Some-what disagree	Do not agree or disagree	Some-what agree	Strongly agree	N/A
The strategic goals of the front end project were fully achieved.	❒	❒	❒	❒	❒	❒
The operative goals of the front end project were fully achieved.	❒	❒	❒	❒	❒	❒
A product concept was defined at a very detailed level.	❒	❒	❒	❒	❒	❒

39. Based on your current information, rate the following statements on front end success: The product, which is based on the developed product concept, will…	Strongly disagree	Some-what disagree	Do not agree or disagree	Some-what agree	Strongly agree	N/A	**Importance of each statement on a scale of 0–2 (see Question 40)**
…provide unique features for the customers compared to the competitors' products.	❒	❒	❒	❒	❒	❒	
…achieve a superior price/quality ratio in target markets compared to competitors' products.	❒	❒	❒	❒	❒	❒	
…provide sustainable competitive advantage for our organization.	❒	❒	❒	❒	❒	❒	
…be aimed at big target markets.	❒	❒	❒	❒	❒	❒	
…be aimed at fast growing markets.	❒	❒	❒	❒	❒	❒	
…solve very important problems of customers.	❒	❒	❒	❒	❒	❒	
…achieve very high customer satisfaction.	❒	❒	❒	❒	❒	❒	
…help our organization to get new market areas.	❒	❒	❒	❒	❒	❒	
…open new (future) product development opportunities.	❒	❒	❒	❒	❒	❒	
…create new market know-how that can be utilized in the future.	❒	❒	❒	❒	❒	❒	
…create new technological know-how that can be utilized in the future.	❒	❒	❒	❒	❒	❒	
…be a very good fit with the company's strategy.	❒	❒	❒	❒	❒	❒	
…be a very good fit with the company's product portfolio.	❒	❒	❒	❒	❒	❒	
…be a very good fit with the company's existing resources (marketing, product development, production).	❒	❒	❒	❒	❒	❒	
…have a good risk/reward ratio.	❒	❒	❒	❒	❒	❒	

40. Using a scale of 0–2 (0 = not important at all, 1 = somewhat important, 2 = extremely important), please indicate how important you consider each statement in the previous question (Question 39) in terms of evaluating the success of the end result of this front end project. Mark your choice in the right-hand column of the table.

41. How soon after the front end project is it possible to measure the success of the end result?

After about _____ months

42. Please indicate which of the following statements is the most accurate description of the current state of the selected front end project:

1 ❒ The development project phase has not started yet
2 ❒ The product was aborted during the development project phase
3 ❒ The product is still in the development project phase
4 ❒ The development project phase of the product has ended
5 ❒ The product is on the market

Note! If you chose 1, 2 or 3 move directly to Question 44.

43. Please indicate how descriptive the following statements are of the success of the product development project:	Strongly disagree	Somewhat disagree	Do not agree or disagree	Somewhat agree	Strongly agree	N/A
No changes needed to be made to the product concept after the front end phase.	❒	❒	❒	❒	❒	❒
All the relevant features of the product concept were considered already in the front end phase.	❒	❒	❒	❒	❒	❒
The product development project was executed within the budget.	❒	❒	❒	❒	❒	❒
The product development project was executed on schedule.	❒	❒	❒	❒	❒	❒
The product achieved high customer satisfaction.	❒	❒	❒	❒	❒	❒
The product met technical specifications.	❒	❒	❒	❒	❒	❒
The product met quality specifications.	❒	❒	❒	❒	❒	❒
The product met profit expectations.	❒	❒	❒	❒	❒	❒
The product met market share expectations.	❒	❒	❒	❒	❒	❒

GENERAL COMPANY INFORMATION

44. Do you have company-wide practices in use to control front end projects?

❒ Yes
❒ No

45. When was the company founded? _____

46. What was the turnover of the company in 2004? About €_____ million

47. What was the R&D spending of the company in 2004? About ____% of turnover

48. What was the total number of employees in the company in 2004? About _____ persons

CONTACT INFORMATION

❒ I want a summary report of the study
❒ I want an invitation to the final seminar of the research project (spring 2006)
❒ I want to receive a book on the front end results of the research project (to be published in spring 2006)

If you have selected any of the three alternatives above, please provide us with your contact information (or enclose your visiting card). Alternatively you can send your contact information by e-mail (jarno.poskela@hut.fi). Note! All responses will be handled with the utmost confidentiality.

Name: _____

Organization: _____

Address: _____

E-mail address: _____

Please return the completed questionnaire with the enclosed prepaid and self-addressed envelope. Completed questionnaires can also be faxed to Jarno Poskela at IMI (fax number: 09-451 3665) or scanned and sent by e-mail to jarno.poskela@hut.fi.

Thank you for your contribution!