MARKET INTELLIGENCE
for
PRODUCT EXCELLENCE

Erik Veldhuizen

Market Intelligence for Product Excellence

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Proefschrift

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Table of contents

Acknowledgments **9**

Chapter 1 Introduction **13**

1.1 Defining market information processing in new product development (NPD) 13
1.2 Relevance of investigating market information processing in NPD 16
1.3 The problem of market information processing in high-tech NPD 18
1.4 Aim and contribution of the research 22
1.5 Overview of the dissertation 24

Chapter 2 Reviewing the literature **27**

2.1 Understanding NPD performance 27
2.1.1 Importance of NPD performance 27
2.1.2 Defining NPD performance 28
2.1.3 Determinants of NPD performance 30
2.2 Achieving product advantage for NPD performance 33
2.2.1 Defining product advantage 33
2.2.2 Theoretical sources of product advantage 34
2.2.3 Empirical studies on market orientation and NPD as sources of product advantage 36
2.3 Representation of the NPD process 38
2.3.1 NPD process models 38
2.3.2 Generic stages of the NPD process 41
2.4 Market information processing in NPD 44
2.4.1 Defining market information 45
2.4.2 Behavioral market orientation 45
2.4.3 Market information processing for NPD performance 47
2.5 Antecedents of market information processing in NPD 49
2.5.1 Structural antecedents of market information processing 49
2.5.2 Cultural antecedents of market information processing 52
2.6 Summary and conclusions 56

Chapter 3 Exploring market information processing with practitioners **57**

3.1 Exploratory interviews with practitioners 57
3.1.1 Findings for the market information processing variables 59
3.1.2 Findings for the antecedents of market information processing 62
3.1.3 Conclusions 65
3.2 Case study: Market information processing in a car navigation system project 65
3.2.1 Case study research design 66
3.2.2 Background of the car navigation project 66
3.2.3 Acquisition of market information 68
3.2.4 Dissemination of market information 72
3.2.5 Use of market information 73
3.2.6 Antecedents of market information processing 75
3.2.7 Summary of case study findings 76

Chapter 4 Building the conceptual framework 79

4.1 Consequences of market information processing 79
4.1.1 Product advantage and new product performance 80
4.1.2 Market information use and product advantage 80
4.1.3 Market information use across NPD stages 81
4.1.4 Market information acquisition, dissemination and use 81
4.2 Antecedents of market information processing 83
4.2.1 Project urgency characteristics 84
4.2.2 Company structural characteristics 85
4.2.3 Company cultural characteristics 89
4.2.4 Summary and conclusions 92

Chapter 5 Research method 95

5.1 Introduction 95
5.2 Questionnaire development 96
5.3 Measure development 97
5.3.1 Measurement of new product outcomes 97
5.3.2 Measurement of market information processing variables 98
5.3.3 Measurement of project urgency characteristics 100
5.3.4 Measurement of company structural characteristics 100
5.3.5 Measurement of company cultural characteristics 101
5.4 Mail survey 103
5.4.1 Survey administration 103
5.4.2 Sampling procedure 104
5.4.3 Sample characteristics 106
5.5 Measure validation 111
5.5.1 Psychometric properties 111
5.5.2 Assessment of psychometric properties 113
5.6 Summary and conclusions 120

Chapter 6 Exploring the conceptual framework 125

6.1 Path analysis with maximum likelihood estimation 125
6.2 Consequences of market information processing 126
6.3 Antecedents of market information processing 132
6.3.1 Project urgency characteristics 134
6.3.2 Company structural characteristics 137
6.3.3 Company cultural characteristics 140
6.4 Analysis of the integrated model 143
6.5 Summary and conclusions 147

Chapter 7 Discussion of the results 149

7.1 Summary of main findings 149
7.2 Product advantage and new product performance 151
7.3 Market information processing 152
7.3.1 Use of market information 152
7.3.2 Dissemination of market information 153
7.3.3 Acquisition of market information 154
7.3.4 Using market information without dissemination 154

7.4 Antecedents of market information processing 155
7.4.1 Project urgency characteristics 155
7.4.2 Company structural characteristics 157
7.4.3 Company cultural characteristics 158
7.5 Limitations and further research 160
7.5.1 Informant issues 160
7.5.2 Methodological issues 162
7.5.3 Measurement issues 163
7.6 Conclusions 165

Summary **167**

Samenvatting **171**

References **175**

Appendices **195**

Appendix 1: Company profiles and interview outcomes 197
Appendix 2: Topics and interview questions of exploratory interviews 200
Appendix 3: Summary statistics and Cronbach's alphas pilot mail survey 201
Appendix 4: Answers to open questions on product description and product benefits 202
Appendix 5: Variables and survey items 210

Curriculum Vitae **215**

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Chapter 1 - Introduction

The present research project investigates the relationships between market information processing and new product performance for new high-tech products. Although the benefits of market information processing are well-known, the effectiveness of market information processing in high-tech new product development (NPD) has been questioned. On the one hand, market information processing is required to reduce high levels of market uncertainty during high-tech NPD. On the other hand, market information processing may be problematic due to the turbulent nature of these environments. The main goal of this project is therefore to obtain an increased understanding of the role that market information processing plays during high-tech NPD.

In addition to the outcomes of market information processing, this research identifies several antecedents of market information processing in high-tech NPD. Much research has focused on the consequences of market information processing, but only a limited number of studies has investigated which factors contribute to, or act as barriers to, market information processing. This is surprising as many companies encounter difficulties with market information processing in high-tech NPD. An additional goal of this research project is therefore to explore the antecedents of market information processing in high-tech NPD.

Chapter one first defines market information processing in NPD and shows the increased interest for this topic in the marketing and NPD literatures (section 1.1). Section 1.2 describes the relevance of investigating market information processing in NPD. Section 1.3 describes why market information processing in high-tech NPD may be problematic. Section 1.4 presents the research questions and the aim and contribution of this project. Section 1.5 concludes with an overview of the remaining chapters of this book.

1.1 Defining market information processing in new product development (NPD)

Market information processing; i.e., the acquisition, dissemination and use of market information, is the main topic of this doctoral dissertation (Adams, Day and Dougherty 1998, Day 1994, Jaworski and Kohli 1993, Kohli and Jaworski 1990, Moenaert and Souder 1990, Moorman 1995, Ottum and Moore 1997, Sinkula 1994, Sinkula, Baker and Noordewier 1997, Slater and Narver 1995). Market information refers to information about customer needs and preferences, and includes an analysis of how those needs and preferences may be affected by exogenous factors such as government regulation, technology, competitors, and other environmental forces (Kohli and Jaworski 1990). Furthermore, market information pertains to both current and future customer needs. According to Kohli and Jaworski (1990) this latter distinction is important because it often takes years for an organization to develop a new product. Thus, market information is defined here as information about both current and

future customer needs as well as factors that may influence those needs.

Acquiring market information is the first key element of market information processing and is the stage in which market information for the subsequent information processing stages is obtained (Adams et al. 1998, Moorman 1995). Information acquisition is an important element of market information processing because, without it, there is no opportunity for the firm to understand its customer and competitor environments (Sinkula et al. 1997). In other words, market information cannot be disseminated or used unless it has previously been gathered. Acquiring information may occur through formal mechanisms such as customer surveys and competitive intelligence activities, or through informal means such as meetings and discussions with customers and trade partners. The information may be gathered through quantitative methods such as market surveys and concept tests, or by qualitative methods such as in-depth interviews or observation studies. Importantly, acquiring information is not the exclusive responsibility of the marketing department; instead market information can be obtained by any functional department in the company (Kohli and Jaworski 1990). For example, information can be gathered through methods in which all members of the product development team come in direct contact with the customer such as emphatic design (Leonard and Rayport 1997) and customer visits (McQuarrie 1998).

The dissemination of market information refers to the diffusion of information to relevant users within the organization. Disseminating market information is critical to NPD because it provides a shared understanding across organizational members (Kohli and Jaworski 1990), which improves the performance of NPD activities (Griffin and Hauser 1993). Dissemination of information occurs through communication and co-operation between different functional areas within an organization and may occur formally or informally, top-down or bottom-up (Kohli and Jaworski 1990, Moorman 1995). By sharing information, organizational members make specific information accessible to other members of the NPD-team (Souder and Moenaert 1992).

The final stage of market information processing is the use of market information (Moorman 1995, Ottum and Moore 1997). The use of market information is defined here as taking information about current and future needs of customers and external factors that impact those needs into account when making NPD decisions (Veldhuizen, Hultink and Griffin 2006, based on Moorman, Deshpandé and Zaltman 1993). For example, market information is used when an NPD-manager decides to add a feature to a new product based on the results of a market study. Zahay, Griffin and Fredericks (2004) found that different types of information are used in different parts of the NPD process. Market information about customer needs and wants is used in both the predevelopment and later in the development stage of NPD. On the other hand, information about the set of potential customers is used in the predevelopment and later in the commercialization stage of NPD (Zahay et al. 2004).

Because of Zahay et al. (2004), in this research project, the use of market information is investigated in three generic NPD stages: predevelopment, development and commercialization. The predevelopment stage contains strategic planning, business and market opportunity analysis, and new product idea generation and evaluation (Rosenau and Moran 1993, Urban and Hauser 1993). During the development stage attention turns to product specification. Product concepts are developed and prototypes are tested with potential customers. In the commercialization stage, product specifications are released to manufacturing and the sales force is trained (Rosenau and Moran 1993). Market introduction of the new product is prepared and decisions on launch strategies and tactics are made (Hultink, Griffin, Robben and Hart 1998). By distinguishing these separate stages, it is possible to determine the relationships between market information use in the different stages and new product outcomes.

In the marketing literature, market information processing activities have been referred to as a firm's market orientation (Kohli and Jaworski 1990, Narver and Slater 1990). The concept of a market orientation has received much attention in the literature and in managerial practice for its apparent positive effect on organizational performance. Since the first articles on the measurement of a market orientation were published (Kohli and Jaworski 1990, Narver and Slater 1990) the number of studies on market orientation has grown exponentially. At the start of this research project, a total of 182 scientific articles had been published on the topic (as cited in ISI Web of Knowledge). By October 2007 the same query resulted in 744 scientific articles with more than 50 articles published annually in each of the last five years (See figure 1.1). In 2006, 106 articles were published on market orientation. This means that the literature base has grown rapidly over the last years, indicating a high interest in this topic.

The concept of a market orientation has also been applied in the field of NPD (Atuahene-Gima 1995). Before the year 2000, only 5 studies had been published on market orientation in NPD, but this number has increased to 61 studies by October 2007. The year 2006 experienced a relatively large number of publications (15 articles) on market orientation and NPD. Therefore, the application of market orientation to NPD has also become an important research area in the academic literature.

The importance of investigating market information processing in NPD is also echoed in the research funding priorities of The Marketing Science Institute (MSI). The history of MSI in supporting research on market information goes back to two initiatives (Deshpandé 2001): (1) the management of marketing information and decision support systems (e.g., Montgomery 1970, Glazer 1989) and (2) the organization of the market research function (e.g., Meyers, Massy and Greyser 1980, Despandé and Zaltman 1982, 1984, 1987). In July 2002, two of the eight research priorities were about innovation and new products, and

collecting, interpreting and using market information. Thus, market information processing and NPD have been and both continue to be major research priorities for the MSI.

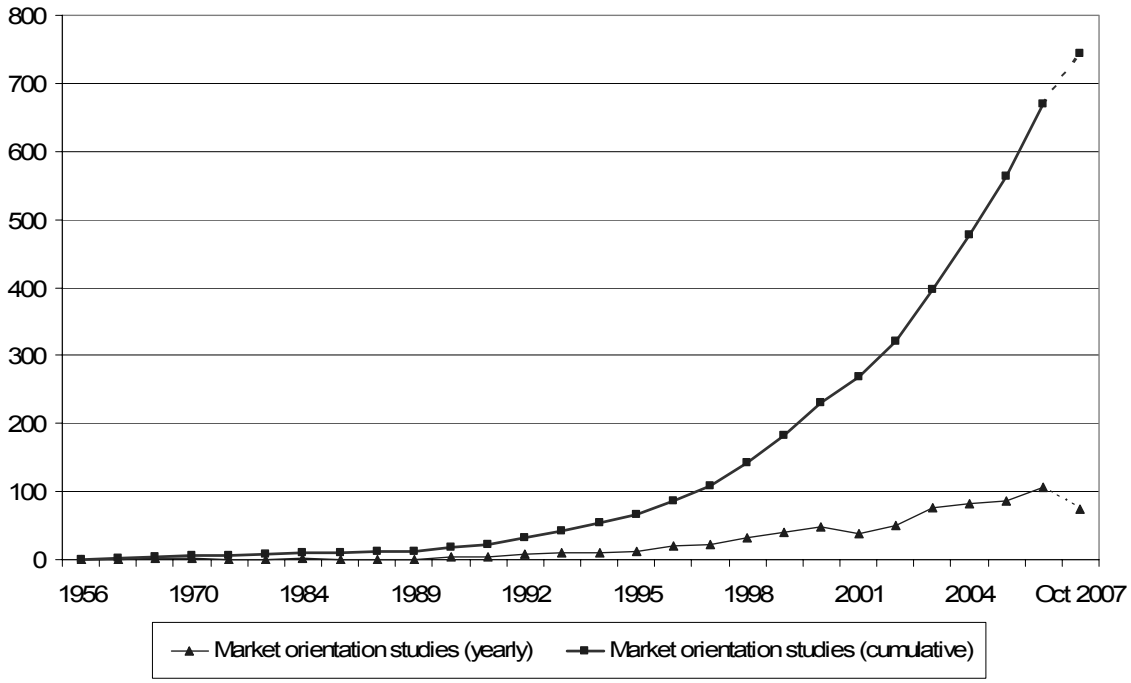


Figure 1.1: Number of studies on market orientation (yearly and cumulative)

1.2 Relevance of investigating market information processing in NPD

Improving innovation performance is high on the agenda of all European governments. In the Lisbon 2000 agreement, European policy makers declared that the European Union (EU) should become the most dynamic and competitive knowledge-based economy in the world by 2010. EU countries agreed to increase R&D spending by governments, universities, and corporations to a total of 3% of the gross domestic product (GDP) within this decade. Furthermore, the transfer of technology across universities, public research labs and private companies should be stimulated in order to increase innovation performance.

However, three years after the Lisbon agreement, European innovation performance was still falling behind the global leaders (World Economic Forum 2004). In 2005, only 1.84% of GDP was spent on R&D in the EU member states on average. In contrast, the U.S. spent 2.67% and Japan spent 3.17% of GDP on R&D (European Commission 2007). A mid-term review of the Lisbon process concluded that little progress had been made and recommended refocusing the agenda on growth and employment (European Commission 2004). As a result, a renewed Lisbon strategy was formulated in 2005 with a longer-term agenda. Supporting knowledge and innovation was again one of the key priorities on this agenda (European Commission 2005).

Despite this innovation stimulating policy, the EU represents a decreasing share of worldwide R&D investments (European Commission 2007). One reason for this declining share is that the newly emerging economies have increased their R&D investments and are no longer competing on the basis of low-cost activities only. China, for example, has approached the EU quickly, in terms of the world's share in exports of high-tech products. Regarding computers, China has become the world's main exporter, and in electronics and telecom China has been ahead of the EU since 2004.

Within Europe, the R&D intensity of the Netherlands in 2005 (1.78%) is close to the EU average. According to the European Innovation Scoreboard (2006), which measures the development of the knowledge-economy in several European countries, the innovation performance of the Netherlands was below the performance of the European innovation leaders such as Switzerland, Sweden, Finland and Denmark in 2006. To become a more knowledge-driven economy, the Netherlands needs to increase the efficiency of R&D and improve the transformation of new ideas into new products.

Stimulating innovation in the Netherlands has become an important issue for the Netherlands Ministry of Economic Affairs. Following the example of Finland, a so-called 'Innovation Platform' chaired by the prime-minister has been instigated in the Netherlands to strengthen the innovation potential of the country. The Netherlands Ministry of Economic Affairs invested 3 billion Euros in stimulating innovation in the period 2004-2007 (National budget 2007). Furthermore, the Dutch government introduced so called 'innovation vouchers' that small and medium-sized enterprises can use to co-operate with knowledge institutions such as universities and research institutes. Together, these policy actions indicate the importance of increasing innovation performance in the Netherlands.

In addition to just spending more money on innovation to improve the innovation performance of the Netherlands, Dutch firms need to increase the success rate of NPD. One potential way to increase this success rate is by using market information during NPD, as previous research has shown that market information plays an important role in successful NPD (Atuahene-Gima 1995, Cooper 1979, Cooper and Kleinschmidt 1987, Griffin and Hauser 1993, Moorman 1995, Ottum and Moore 1997). For example, Ottum and Moore (1997) found that in 75 percent of the product failures studied, companies' processed less than the average amount of market information, whereas companies processed more than the average amount of market information during the project in 80 percent of the new product successes. According to Cooper (2001) the absence of market information use is the leading cause of new product failure. Poor market research, a failure to build in the voice of the customer, lacking competitive analyses and a poor understanding of market trends are common weaknesses found in many studies on new product failures (Cooper 2001).

One example of a product where the absence of market research led to trouble is Segway (See figure 1.2), the world's first self-balancing, electric-powered personal transportation device invented by Dean Kamen (U.S.). During the development process, the Segway team failed to analyze how the product would meet market needs. Kamen, the inventor, prevented any market testing because he was afraid that other manufacturers would discover and steal the project. Furthermore, he thought that he could not rely on customers, because "they hadn't thought about the problem deeply enough to envision innovative solutions". Later, the team discovered that customers preferred to walk for short distances as an alternative to using the Segway. Instead of using these findings as a warning, the team moved forward. In December 2001, Segway was presented to millions of viewers on U.S. television. Unfortunately, the hype around the introduction did not result in new product sales. In the first 18 months approximately 6,000 Segways had been sold, although a plant had been built that could produce 40,000 units per year (Kemper 2003, Pinegar and Cohen 2004). Although Segways can nowadays be spotted at several places around the world, most frequently being used by security personnel in airports and police officers, it never became the revolutionary mass transportation device that changed the world.



Figure 1.2: Segway

The absence of market research during the development of Segway is not unusual. Many organizations experience difficulties with market information processing in NPD. The acquisition of market information is often omitted during NPD projects. For example, in a benchmarking study of NPD practices in 105 U.S. businesses, Cooper, Edgett and Kleinschmidt (2004a) found that conducting a detailed market study was one of the weakest areas in NPD. The dissemination of market information is also a problem for many firms. Communication barriers between different functional departments often lead to ineffective information sharing (Griffin and Hauser 1996). Adams et al. (1998) found that the diffusion of market information in NPD is often hindered by 'compartmentalized thinking' because people focus on their own goals, which are often defined within their department's role instead of the overall goals of the project. Furthermore, organizations sometimes fail to use market information and do not actively incorporate market information into their new products (Maltz and Kohli 1996, Ottum and Moore 1997). Particularly in high-technology industries, market information processing has been identified as a problematic area (Mohr et al. 2005).

1.3 The problem of market information processing in high-tech NPD

High-tech products are defined as innovative products that are developed in turbulent environments where technologies move quickly and markets are uncertain (Mohr et al. 2005,

Moriarty and Kosnik 1989, Shanklin and Ryans 1987). Typical examples of new high-tech products are Apple's iPhone, Sony's Mylo communicator, and Nintendo's Wii (see Figure 1.3). Although these examples are all consumer products, many high-tech products are developed for industrial customers (e.g., optical devices and industrial machinery).



Figure 1.3: Apple's iPhone, Sony's Mylo communicator, and Nintendo's Wii

The development process of high-tech products is characterized by high levels of market uncertainties (Mohr et al. 2005, Moriarty and Kosnik 1989). Although there are market uncertainties in virtually every industry, the development of high-tech products is different. During the development process of high-tech products, competitors often are not present yet, and potential customers may be difficult to identify (Day 2000). In addition, many product functions will be new to potential customers, and it may therefore be difficult for customers to tell in advance how they feel about a new function (Day 1998, Tauber 1974). Information on the market will often be qualitative, abstract, the result of educated guesses, and sometimes even wrong and invalid, especially in early stages of the NPD process (O'Connor 1998, Veryzer 1998).

Because of these market uncertainties, the development process of new high-tech products may require a high level of market information processing not just before development has begun, but throughout the entire project. Daft and Huber (1987) suggest that the highest levels of information processing occur when an organization is in a rapidly changing environment, in an emerging industry, or undergoing rapid technological development. In a study of market research activities of high-technology firms, Cooper and Little (1977) found that the development of more innovative products required more market investigations than less innovative products. In addition, Teece, Pisano and Shuen (1997) observed that successful firms in high-tech markets could respond in a timely manner to environmental changes with rapid and flexible product innovation by constantly scanning their market environments. According to these studies, the development of high-tech products needs market scanning and the gathering of market information to reduce market uncertainty.

However, there is much controversy about the supposedly positive effects of market information processing in high-tech NPD. Several studies have warned about the potential risks of using market information (e.g., Bennett and Cooper 1981, Christensen 1997, Christensen and Bower 1996, Hamel and Prahalad 1994, Martin 1995, Tauber 1974, Ulwick 2002). This controversy focuses around the following problems: (1) customers may have difficulties in envisioning the future, (2) customers may lack the right frame of reference to evaluate emerging new product concepts, (3) the focus on current customers could lead companies to miss emerging markets, and (4) the prediction of future markets is difficult if they do not yet exist.

Envisioning the future

According to Shanklin and Ryans (1987), understanding customer needs is less important for high-tech products because customers do not always have explicit needs for products until they are introduced to the market. Managers in technology-driven firms often believe that customers never come up with the most valuable innovations. Indeed, customers can identify problems they experience, but most cannot develop new solutions (Ulwick 2002). Hamel and Prahalad (1994) explain that customers are unable to envision innovative products and seldom ask for new products they eventually come to value. In their view, customers are lacking in foresight and would have never asked for cellular phones, for example. Although there was a clear need for mobile communication in remote areas, it was not until the introduction of the second generation mobile phone system in the 1990s that the average consumer started to envision how the technology would benefit them.

Evaluating emerging new product concepts

One reason that is often given for not using market information in high-tech contexts is that customers' product evaluations may be unreliable. When evaluating initial new product concepts, customers often view the first imperfect versions of a new product and compare those with refined versions of existing products (Day 1998). This problem is often called functional fixedness; i.e., the tendency of people to evaluate new product ideas in terms of what they already know (Ulwick 2002, Von Hippel 1986). Especially in the case of innovative products, it is difficult for customers to understand the product concept adequately enough to evaluate it appropriately (Tauber 1974). Therefore, the use of market information during high-tech NPD may be misleading and could lead to me-too products and imitations rather than truly innovative products (Bennett and Cooper 1981, Tauber 1974).

Focus on current customers

Another risk of market information processing during high-tech NPD is that it may give too

much attention to current customers. It is dangerous to focus solely on the needs of current customers as current customers are only a portion of the total market (Day 1999). If firms listen too closely to current customers they may overlook new technologies that are attractive to other non-customers or to small and emerging markets (Christensen and Bower 1996). This focus makes them vulnerable to an unexpected attack by outsiders. Firms should not focus narrowly on serving current customers only, but they should also watch for the emergence of underserved or unserved segments.

In the game-console industry, Nintendo learned this hard lesson. In the early nineties the company was the market leader, and they were developing products they thought were right for their young customers. At the same time, two competitors entered the field with game-consoles and realistic games for young-adult gamers, opening up a new market. Within a short period Sony's Playstation became the dominant player and in less than three years Microsoft's X-Box gained a worldwide market share equaling that of Nintendo's GameCube. Recently, Nintendo has increased its market share after the market introduction of the Wii game console with a revolutionary wireless motion-sensing remote control ('Wii-mote'). The Nintendo Wii is also popular among adult-gamers and, as a result, sales grew quickly. Nintendo sold nearly six million consoles within the first 5 months after market introduction (Nintendo Co., Ltd. 2007). Therefore, the market introduction of the Wii, with it's new to the firm target market of adult gamers, helped Nintendo to regain market leadership in the game console industry.

Prediction of future markets

Christensen (1997) argued that markets for disruptive innovations cannot be predicted with great accuracy because they do not yet exist. During development it is not clear who the most attractive customers will be and how large the potential market will become. In addition, for innovative products, there are no sales histories to study and potential competitors will be unknown. Some captains of industry also are skeptical of the market information that is available and believe that if markets don't exist, they can't be analyzed (Christensen, Johnson and Rigby 2002). Sony's former president Akio Morita, for example, believed that the public should be led with new products rather than being asked what kind of products they want (Hamel and Prahalad 1994).

To summarize, there is a debate about the importance and utility of market information processing in high-tech NPD. On the one hand, the development of high-tech products requires a high level of market information processing because of the many market uncertainties encountered in these projects (Daft and Huber 1987). On the other hand, several studies have warned for the potential risks of market information processing in high-tech NPD. Customers may have difficulty in envisioning the future, or suffer from functional

fixedness and firms' focus on current markets could eventually lead to missing emerging markets (Bennett and Cooper 1981, Christensen and Bower 1996, Hamel and Prahalad 1994, Tauber 1974).

1.4 Aim and contribution of the research

The primary purpose of this doctoral dissertation is to develop a better understanding of the role that market information processing plays during the development process of new high-tech products. By investigating the separate components of market information processing (acquisition, dissemination and use) in three generic stages of NPD (predevelopment, development and commercialization) a comprehensive framework of differential relationships is produced. A main goal of this research project is, therefore, to determine the consequences of market information processing in the different stages of the high-tech NPD process.

A secondary purpose of this research project is to identify project and company characteristics that facilitate market information processing in high-tech NPD. As many organizations experience difficulties with market information processing, it is important to find out how market information processing in high-tech NPD can be enhanced. Gaining more insight into these antecedents could provide companies with guidelines on how to stimulate market information processing during the development of new high-tech products.

This doctoral thesis thus addresses the following general research question:

> *What are the antecedents and consequences of market information processing during the development process of new high-tech products?*

This general question can be broken down into three more specific research questions:

1. What are the characteristics of market information processing during the development process of new high-tech products?
2. What are the consequences of market information processing during the development process of new high-tech products?
3. What are the antecedents of market information processing during the development process of new high-tech products?

By answering these questions, this dissertation aims to contribute to the marketing and NPD literatures in several ways. First, as described in section 1.3, it aims to help unravel parts of the controversy around the importance of market information processing in high-tech NPD. By investigating the consequences of market information processing for high-tech products, this doctoral research will show empirically whether the effects of market information processing on high-tech new product outcomes are either positive or negative.

Second, most market orientation studies have been conducted at the company level. The present study contributes to the literature by operationalizing the market orientation concept at the NPD-project level. Kohli and Jaworski (1990) stress that organizations differ in the extent to which they process market information, and conceptualize the market orientation of an organization as one of degree on a continuum, rather than as being present or absent. Different NPD projects within one organization may also have different degrees of a market orientation. Although both the marketing and NPD literatures acknowledge the importance of having a market orientation, almost no research operationalizes a market orientation at the NPD project level (Kok, Hillebrand and Biemans 2003). Therefore, this research project adapts the concept of a market orientation to the NPD project level. Based on the outcomes of this research, managers may be able to implement a market orientation in the context of an NPD project.

This research also investigates market information use across three generic stages of the NPD process (predevelopment, development and commercialization), and thereby shows the consequences of market information use more granularly than previous studies. These different stages in the development process require different types of market information and using this information may have different effects (Zahay et al. 2004). Most previous empirical research has considered only the extent to which market information is used overall in the project.

Fourth, this research project investigates how the components of market information processing (acquiring, disseminating, and using market information) are related to each other. It is posited that information must be acquired before it can be disseminated, and disseminated before being used. Previous empirical research in marketing has predominantly assumed that the three constructs were directly related to outcomes, rather than investigating their interrelationships.

Finally, this dissertation investigates the effects of several antecedents of market information processing for high-tech products. An important goal is therefore to determine which factors contribute to, or act as barriers to, market information processing in high-tech NPD. This research identifies three sets of antecedents of market information processing: project urgency characteristics (indicating the sense of urgency that is experienced during a project), company structural characteristics (describing how organizational tasks are formally divided, grouped and coordinated) and company cultural characteristics (representing different organizational values and beliefs).

To summarize, this dissertation contributes to the existing literature by providing insight into the antecedents and effects of market information processing at the project level for new high-tech products. This research investigates the interrelationships among acquisition, dissemination and use of market information and shows how the use of market

information at different stages of the NPD process relates to new product outcomes. The results provide initial answers to the question of whether and how market information processing affects new product performance during high-tech NPD.

1.5 Overview of the dissertation

Chapter 2 provides an extensive review of the literature to identify potential antecedents and consequences of market information processing in high-tech NPD. The chapter starts with a description of NPD performance, the ultimate dependent variable in this research. After that, chapter 2 describes product advantage as a dominant driver of new product performance. Aided by the resource based view of the firm, chapter 2 considers market information processing in NPD as an important source of product advantage. Chapter 2 continues with a review of NPD process models to support the use of a generic three-stage model of NPD consisting of predevelopment, development and commercialization stages. Next, the chapter describes the behavioral market orientation literature to develop a market information processing model that distinguishes between acquisition, dissemination and use of market information in the three generic stages of NPD. After developing the individual components of market information processing, chapter 2 concludes with a discussion of several potential antecedents of market information processing in high-tech NPD from the market orientation, R&D/marketing interface and high-tech marketing literatures.

Chapter 3 describes the results from 11 exploratory interviews with NPD managers in several firms and a case study based on interview data from eight managers in a single firm. The objective of this qualitative research is to uncover antecedents of market information processing in addition to the ones found in the literature, and to explore the role of market information processing in high-tech NPD. The interviews revealed several new antecedents to market information processing for high-tech products, such as project priority (indicating the importance of a project) and R&D dominance (a cultural characteristic that gives a high status to technical personnel).

Chapter 4 presents the conceptual framework and hypotheses by synthesizing the results from the literature review (chapter 2) and the interviews with practitioners (chapter 3). The chapter contains two parts. First, chapter 4 develops the hypotheses for the consequences of market information processing in three generic stages of the NPD process. This first part also presents hypotheses for the interrelationships among the components of market information processing to investigate a potential temporal ordering among these constructs. The second part of chapter 4 presents hypotheses for the antecedents of market information processing in high-tech NPD.

Chapter 5 presents the research methodology used to specify the conceptual framework. The chapter describes the mail survey research method and the measures that

were used for specifying the conceptual framework. Then, the chapter describes the procedure of selecting respondents and the sample characteristics. Chapter 5 concludes with the development and validation of the measures.

Chapter 6 describes the results of specifying the conceptual framework with structural equation modeling. First, chapter 6 presents the results of analyzing the antecedents and consequences of market information processing in high-tech NPD separately across four different structural equation models. The chapter concludes with an integrated model that combines the results from the separate analyses.

Chapter 7 discusses the results and presents managerial and research implications. A discussion with twelve practitioners during a feedback-seminar aided the interpretation of the findings. Therefore, chapter 7 also presents the results of this discussion. In addition, the chapter describes the limitations of this research project and provides suggestions for further research. Finally, chapter 7 draws conclusions and summarizes the main contributions of this research project.

Chapter 2 – Reviewing the Literature

Chapter two reviews the literature on market information processing and new product development (NPD). The goal of this chapter is to identify antecedents and consequences of market information processing in high-tech NPD. The chapter starts with two potential outcomes of market information processing: product advantage and NPD performance.

After describing product advantage and NPD performance, the chapter continues with exploring the processes by which firms create these outcomes. First, the resource based view of the firm (RBV) is discussed to show how NPD can be a capability that firms use to create product advantage. For developing new products, firms often use a stage-wise NPD approach. Based on a review of NPD-process models, this chapter presents a three-stage model of NPD consisting of predevelopment, development and commercialization stages. Subsequently, the behavioral market orientation literature is discussed to develop a market information processing model that distinguishes among the acquisition, dissemination and use of market information.

The chapter concludes with a discussion of antecedents of market information processing in high-tech NPD. Both company structural characteristics and company cultural characteristics are identified from the market orientation, marketing/R&D interface and high-tech marketing literatures as important determinants of market information processing.

2.1 Understanding NPD performance

2.1.1 Importance of NPD performance

In the present global knowledge economy, technology and innovation are important determinants of economic growth (OECD 2004). Innovation is important for economic growth because it makes a contribution to increased productivity and higher employment rates (European Commission 2007). Thus, the degree to which firms are able to develop new products and bring them to the market successfully determines the economic prosperity of many nations.

NPD is also important for the growth and survival of individual firms. NPD is probably one of the most important processes for many companies as it influences the revenues and margins that a company can achieve and it has a positive impact on firm value (Pauwels, Silva-Rosso, Shrinivasan and Hanssens 2004). The NPD literature has consistently shown that NPD performance is positively related to organizational performance (Cooper 2001, Griffin and Page 1996, Hultink et al. 1998, Langerak, Hultink and Robben 2004a, Montoya-Weiss and Calantone 1994). The most recent PDMA best practice study showed that, among the best performing firms, 48% of sales are derived from new products introduced in the last five years (Adams and Doug 2004). In addition, ninety percent of executives recently

surveyed by Booz Allen Hamilton mentioned that the introduction of new products and services is crucial to profitable growth (Beerens, Goldbrunner, Hauser and List 2005). An example of the impact of successful new products on firm performance is shown in Exhibit 2.1, which explains how the introduction of the iPod boosted Apple's sales. Within six years, the iPod has generated nearly 40 percent of Apple's total sales. In the same period Apple's sales revenue more than tripled, indicating the importance of new products for a firm's growth.

Besides its impact on organizational performance through increased profits and sales, new product introductions may also influence the firm's market value through higher stock market valuations. One reason for this is that stock market investors value the expected cash flows that result from a new product. The higher the expectation of these future cash-flows, the more the firm's stock price will increase and the higher the firm value becomes. Pauwels et al. (2004) empirically investigated the effects of new product introductions on stock prices in the automotive industry and found that new product introductions have both a positive short- and long-term impact on the firm's top-line (revenue), bottom-line (earnings), and stock market performance. The example of Apple's iPod confirms these empirical findings.

2.1.2 Defining NPD performance

Both academics and practitioners agree that measuring NPD performance is important (Griffin and Page 1993). However, measuring new product performance is not easy. Several researchers have suggested that new product performance is multidimensional and that success can be measured in different ways (Griffin and Page 1996, Hart 1993, Marsh and Stock 2003).

There are many performance criteria available to determine whether a new product is a success or a failure (Griffin and Page 1993, Hultink and Robben 1995). For example, Marsh and Stock (2003) proposed that performance in NPD can be assessed at three different levels: project level (e.g., time, cost efficiency and functional performance), product level (e.g., profitability, market share and revenues of the new product) and firm level (returns to the firm generated by the new product). In a meta-study on NPD success factors, Montoya-Weiss and Calantone (1994) found three broad categories of new product performance measures: (1) financial objectives, (2) market share objectives, and (3) technical objectives. The financial and market share objectives both were considered to be measures of commercial performance. It turned out that all studies in their review considered measures of commercial performance, and only four of the forty-seven studies considered technical objectives. Therefore, the authors used only studies based on commercial measures of NPD success in their meta-analysis.

Exhibit 2.1 – The impact of Apple's iPod on firm performance

One example of the potential impact of new products on firm performance is the market introduction of Apple's iPod. In October 2001, Steve Jobs (CEO, Apple Computer Inc.) unveiled the first iPod digital music player. Less than six years later, iPod dominated digital music player sales. On April 9, 2007 Apple announced that the 100 millionth iPod had been sold, making the iPod the fastest selling music player in the world. More than 40% of Apple's sales were outside the U.S., reflecting the popularity of the iPod globally.

Table 1 shows Apple's and iPod sales history starting from the introduction of the first generation iPod until quarter 3 of financial year 2007 (Q3 2007). In financial year 2006, Apple sold nearly 40 million iPods worldwide, generating sales of more than $7.6 billion, almost 40 per cent of Apple's total revenue. In the holiday shopping season (Q1 2006) more than half of Apple's total sales consisted of iPod sales.

Altogether, the success of the iPod, has helped Apple to become one of the best performing stocks in the Standard & Poor's 500 Index. Between July 2002 and July 2007 the stock price rose from a value of about $7 per share to $140 per share.

Table 1: iPod sales in units and dollars over the period July 2002 – July 2007

Quarter of Fiscal Year	iPod Units x 1,000	iPod Revenue x M$	Apple's Revenue x M$	iPod revenue as % of Apple's revenue
Q4 2002	140	$53.00	$1,443.00	3.67%
Q1 2003	219	$81.00	$1,472.00	5.50%
Q2 2003	80	$31.00	$1,475.00	2.10%
Q3 2003	304	$111.00	$1,545.00	7.18%
Q4 2003	336	$121.00	$1,715.00	7.06%
Q1 2004	733	$256.00	$2,006.00	12.76%
Q2 2004	807	$264.00	$1,909.00	13.83%
Q3 2004	860	$249.00	$2,014.00	12.36%
Q4 2004	2,016	$537.00	$2,350.00	22.85%
Q1 2005	4,580	$1,211.00	$3,490.00	34.70%
Q2 2005	5,311	$1,014.00	$3,243.00	31.27%
Q3 2005	6,155	$1,103.00	$3,520.00	31.34%
Q4 2005	6,451	$1,212.00	$3,678.00	34.73%
Q1 2006	14,043	$2,906.00	$5,749.00	50.55%
Q2 2006	8,526	$1,714.00	$4,359.00	39.32%
Q3 2006	8,111	$1,497.00	$4,370.00	34.26%
Q4 2006	8,729	$1,559.00	$4,837.00	32.23%
Q1 2007	21,066	$3,427.00	$7,115.00	48.17%
Q2 2007	10,549	$1,689.00	$5,264.00	32.09%
Q3 2007	9,815	$1,570.00	$5,410.00	29.02%

(Source: Based on financial reports, Apple Computer Inc.)

Based on a review of 77 publications and a survey of 50 practitioners, Griffin and Page (1993) identified 75 different measures of new product performance used by academics or practitioners. Expert grouping by a group consensus process and factor analysis resulted in five general independent categories of success and failure measures: (1) measures of firm benefits, (2) program-level benefits, (3) product-level measures, (4) measures of financial performance, and (5) measures of customer acceptance. A comparison of the measures that academics use with the measures practitioners use or would like to use resulted in 16 core measures that everyone uses or wants to use to assess the performance of a single product development project. Three independent dimensions were identified underlying these measures: consumer-based, financial-based, and technical or process-based measures of success. Hultink and Robben (1995) showed the relevance of these 16 core measures for managers in Dutch companies. Based on these empirical findings, this research project defines NPD performance at the project level as the extent to which a new product has achieved its consumer-based, financial, and technical or process-based objectives.

2.1.3 Determinants of NPD performance

Over the last thirty years many empirical studies have investigated the determinants of new product performance (e.g., Cooper 1979, Cooper and Kleinschmidt 1987, Maidique and Zirger 1983, Rothwell 1972, Utterback, Allen, Hollomon and Sirbu 1976). Together, these studies have identified a large set of factors that are associated with the success or failure of new products. Two important meta-studies have been conducted to summarize the NPD performance literature and statistically compare the findings (see Table 2.1). Montoya-Weiss and Calantone (1994) synthesized 47 empirical studies and investigated 18 determinants of NPD success related to four categories (new product strategy, development process execution, organization, and the market environment). More recently, Henard and Szymanski (2001) found 60 empirical studies and included 24 determinants of new product performance organized into four different categories (product, firm strategy, firm process and marketplace characteristics) in their meta-analysis. Both frameworks are similar, except for product characteristics (such as price, technological sophistication and innovativeness) that are specified in more detail by Henard and Szymanski (2001).

Both studies used meta-analytical techniques to statistically compare the empirical results of previous research on NPD success factors and to determine which factors are dominant drivers of new product performance across different studies. Montoya-Weiss and Calantone (1994) found that all 18 factors were statistically significant. Further inspection of correlation effect sizes showed that product advantage was one of the key success factors. The four largest average absolute correlations were product advantage, protocol, proficiency

of marketing activities, and strategy. These findings show that product advantage and development process factors were major drivers of new product performance.

Table 2.1: Meta-studies on determinants of NPD performance

Authors of meta-studies	**Determinants of NPD Performance**
Montoya-Weiss and Calantone (1994)	New product strategy **Product advantage, marketing synergy, technological synergy, strategy, company resources**. Development process execution **Protocol, proficiency of predevelopment activities, proficiency of market-related activities, proficiency of technological activities, top management support, control and skills, speed to market, costs, financial/ business analysis**. Organization **Internal/external communication, organizational factors**. Market environment **Market potential, market competitiveness, and environment**.
Henard and Szymanski (2001)	Product characteristics **Product advantage, product meets customer needs, product price, product technological sophistication**, product innovativeness. Firm process characteristics **Structured approach, predevelopment task proficiency, marketing task proficiency, technological proficiency, launch proficiency, reduced cycle time, senior management support**, market orientation, customer input, cross-functional integration, cross-functional communication. Firm strategy characteristics **Marketing synergy, order of entry, dedicated human resources, dedicated R&D resources**, technological synergy. Marketplace characteristics **Likelihood of competitive response, market potential**, competitive response intensity.

Note: statistically significant drivers of NPD performance are **bolded**.

Henard and Szymanski (2001) examined the mean correlations from 41 studies and found that 17 factors were significantly related to performance and that 10 factors representing all four categories can be considered dominant drivers of new product success. In addition to the bivariate analysis of correlations, Henard and Szymanski (2001) estimated

a multivariate regression model of new product performance. The results showed that product advantage was most strongly related to new product performance. Surprisingly, the correlations of seven traditional determinants of new product performance, such as market orientation, customer input and cross-functional communication were not statistically significant and do not generalize across different studies. One potential explanation for this finding is that the effects of these variables can be indirectly realized by their influence on other determinants of new product performance such as product advantage.

To explain the variations in results of previous studies, Henard and Szymanski (2001) investigated whether measurement factors (such as objective versus subjective measurement) and contextual factors (such as high-technology versus low-technology markets) had an impact on the meta-analytical findings. The authors found that both measurement factors and contextual factors make a difference for estimating performance relationships. This means that there may not be a single set of determinants of NPD success for all situations, but rather a set of key determinants of performance that depends upon the context. In the case of high-technology markets, which is the context of this research project, Henard and Szymanski (2001) found that product advantage, product technological sophistication, and dedication of human resources were dominant drivers of performance. Furthermore, being first to market and using a structured approach may detract from performance in high-tech markets.

To conclude, product advantage has consistently been identified as a dominant driver of new product performance and is important in the context of high-technology industries as well. In high-technology markets that are turbulent, complex and uncertain, firms need sophisticated products that have an advantage over other offerings in order to be successful (Henard and Szymanski 2001). Furthermore, product advantage may be an important mediator between the effects of certain process characteristics (such as market orientation and cross-functional integration) and new product performance. Process characteristics have often been studied as direct antecedents of new product performance, sometimes leading to statistically insignificant results (Henard and Szymanski 2001). Instead of a direct relationship, certain antecedents may influence performance indirectly by affecting other determinants of performance. Product advantage can be considered as an outcome of the NPD-process, and it may therefore act as a mediator between process characteristics and new product performance. To find out which process characteristics can influence product advantage, the next section reviews the theoretical and empirical literatures on the sources of product advantage.

2.2 Achieving product advantage for NPD performance

This research investigates the potentially mediating role of product advantage between other possible success factors and project success because the creation of product advantage has consistently been found as the predominant success factor in achieving NPD performance (e.g., Cooper 1985, Song and Parry 1997). According to Cooper (1979), the important role of product advantage in influencing NPD performance is not surprising, because it is through the product that firms must obtain their differential advantage in the market. The current section defines product advantage and integrates findings from the resource based view of the firm with empirical findings from the NPD literature to show how companies can influence product advantage.

2.2.1 Defining product advantage

Product advantage is the intended outcome of the NPD process. It has often been referred to as relative advantage in research on the adoption of innovations (Rogers 2003). Gatignon and Xuereb (1997) defined relative advantage in terms of product attributes, benefits and image relative to competitive product offerings. Product advantage has sometimes been referred to as product quality, measuring the extent to which a product is superior to competing products. For example, Sethi (2000) defined product advantage or new product quality as the extent to which a new product is superior to competing products in aesthetics, performance, life, workmanship and safety. Similarly, Calantone and di Benedetto (1988) referred to superior product quality in the eyes of the customers when the product had higher specifications, was more reliable or was more durable than competitive offerings. Additionally, Li and Calantone (1998) measured product advantage of software products with items such as productivity, reliability and compatibility, which also refer to different dimensions of product quality. Although product quality is certainly an important element of new product advantage, the focus in this research is on multiple characteristics of product advantage, including product quality.

Product advantage is defined here as the new product's superiority over competing products in the eyes of the customer. Product superiority involves the incorporation of unique features, a higher quality, solving customer problems better, and a reduction of customers' costs in comparison to the competition (Cooper and Kleinschmidt 1987). By referring to the product's superiority in the eyes of the customer, this conceptualization emphasizes both the viewpoints of the customer and the competitor (Hultink and Hart 1998, Rijsdijk, Hultink and Diamantopoulos 2007).

2.2.2 Theoretical sources of product advantage

As product advantage plays an important role in the development of successful products, the investigation of the sources of advantage has become important. The current section explains the creation of product advantage through elements of the resource-based view of the firm (RBV).

Firmly grounded in the strategy literature, the RBV builds upon the idea that a firm's competitive advantage is largely determined by the resources it owns and controls (Barney 1991, Penrose 1959, Wernerfelt 1984). The RBV tries to identify those firm-specific factors that underlie a firm's competitive advantage. A firm is said to own a competitive advantage when it creates superior value for its customers and generates profits that are larger than the average of its industry (Day and Wensley 1988). Superior customer value may consist of cost advantages by offering products at a lower price than competitors, or differentiation advantages when a new product is perceived as being superior to competing alternatives (Day and Wensley 1988, Porter 1985). According to the RBV, combinations of a firm's resources lead to the creation of superior customer value, which in turn influences the firm's market performance. Similarly, many NPD studies identify both cost and differentiation advantages (often referred to as product advantage) as important determinants of new product performance (Song and Parry 1997). The RBV is therefore adopted as a theoretical framework to explain which resources help firms to create product advantage.

The RBV assumes that firms can be conceptualized as bundles of resources and that there are differences in the allocation of those resources across firms. According to Wernerfelt (1984) the possession of resources explains important firm outcomes. In trying to deliver superior value to customers, firms are limited by the resources they possess and, as a result, performance differences across firms emerge (Wernerfelt 1984). This means that resources take a central position in the RBV (Eisenhardt and Martin 2000).

Resources are typically defined as combinations of assets and capabilities (Day 1994, Day and Wensley 1988). *Assets* are used as inputs to organizational processes and may be tangible or intangible. Tangible assets refer to the fixed and current assets of an organization with a value that is relatively easy to measure. Intangible assets, on the other hand, represent resources that are non-physical in nature and that are more difficult to measure and to duplicate (Barney 1991). Examples of intangible assets are a firm's patents, brands, and knowledge bases. By combining tangible and intangible assets firms are better able to sustain their competitive advantages. However, in order to create a competitive advantage a firm needs capabilities, or skills, to do so.

Capabilities are defined as "complex bundles of skills and collective learning, exercised through organizational processes that enable firms to coordinate activities and make use of their assets." They are the 'glue' that bring assets together and are 'deeply

embedded' in the organizational routines and practices (Day 1994, p.38). Capabilities are said to be the most difficult resources to duplicate because they are tacit in nature and embedded in the organization (Teece et al. 1997). Day (1994) made a valuable distinction between three types of capabilities: inside-out, outside-in and spanning capabilities (see Figure 2.1).

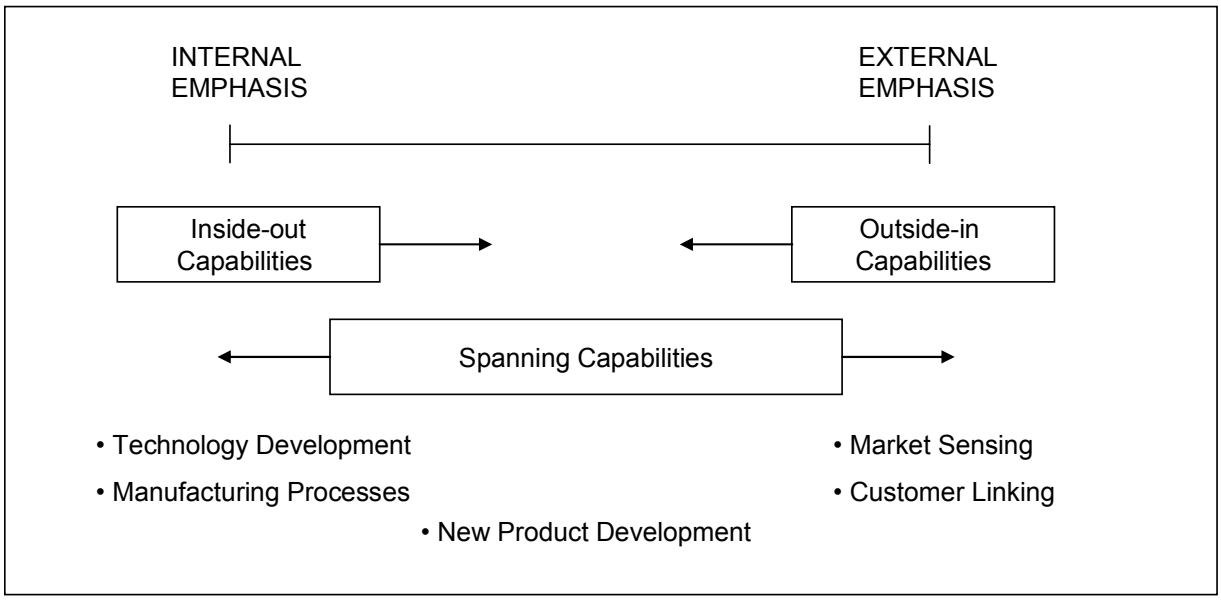


Figure 2.1: Classification of capabilities (Day 1994)

At one end of the continuum are so called inside-out capabilities that have an internal emphasis. For example, technology development and manufacturing processes are organizational processes that are internally oriented. At the other end of the continuum are the outside-in capabilities that connect organizational processes to the external environment. Examples are market sensing and customer linking capabilities. The purpose of these outside-in capabilities is to anticipate market developments ahead of competitors and to maintain relationships with customers, channel members and suppliers. This external focus links the RBV to the market orientation, organizational learning, and innovation literatures. For example, Sinkula (1994, p.37) suggests that market-directed organizational learning "results in the fundamental bases of competitive advantage". According to Day (1994), continuous market learning helps managers repeatedly anticipate market opportunities and respond before their competitors, providing the opportunity to create competitive advantage for the firm.

In order to integrate the inside-out and outside-in capabilities, Day (1994) introduced spanning capabilities. NPD is a typical example of a spanning capability as it should be informed by both internal and external analyses. Dickson (1992) suggests that firms that observe and analyze their markets (capabilities that help them build their knowledge bases)

are more likely to spot opportunities and by changing their behavior (i.e., by developing new products) to these technological and market insights, companies may be able to create a competitive advantage. The complete framework suggests that NPD is a spanning process that links technology development as an inside-out process to market scanning as an outside-in process.

Taken together, assets and capabilities can lead to competitive advantages based on innovative offerings that deliver superior customer value or lower relative costs. To protect the advantages from being competed away, firms have to set up barriers in the form of isolating mechanisms that make imitation difficult. Barney (1991) discussed some of these mechanisms and explained that resources must be valuable, rare, and difficult to imitate or substitute in order to create a sustained competitive advantage. In this perspective, market information processing (defined in chapter 1 as the acquisition, dissemination and use of market information) can be viewed as a capability that may be protected with isolating mechanisms: Market information processing is valuable, because it may offer market insights that are not available to others; it is rare, because it may be difficult and costly to obtain valid market information; and it is difficult to imitate because market information processing is embedded in organizational activities that are difficult to observe from the outside (Li and Calantone 1998, Wei and Morgan 2004).

To summarize, NPD can be considered as a spanning capability that integrates outside-in and inside-out capabilities. Furthermore market information processing is an important outside-in capability that can be protected with isolating mechanisms and when implemented in NPD, it may help companies to create a competitive advantage.

2.2.3 Empirical studies on market orientation and NPD as sources of product advantage

In addition to the theoretical literature on the RBV, several studies have investigated empirically whether product advantage is influenced by market information processing. For example, Atuahene-Gima (1995) investigated the effects of a market orientation on product advantage. Market orientation was measured as the collection and use of market information, the development of a market-oriented strategy, and the implementation of a market-oriented response to customer needs. The results, based on data from 275 Australian firms, showed that a firm's market orientation was positively related to product advantage.

Langerak et al. (2004a) investigated the relationship between a market orientation, NPD launch activities and product advantage. Market orientation was operationalized as the combination of a customer orientation, competitor orientation and inter-functional coordination. The results, based on a survey of 126 firms in the Netherlands, showed that

market orientation had a positive and significant impact on both launch activities and product advantage.

Li and Calantone (1998) investigated the differential effects of customer knowledge processes, competitor knowledge processes and the R&D/marketing interface at the NPD-program level on product advantage. The results, based on survey-data from 236 NPD-projects in the U.S. software industry, showed that each of the three processes had a positive and significant influence on product advantage.

Thus, according to these findings, market orientation plays a major role in achieving product advantage. In addition to the influence of a market orientation on product advantage, several studies investigated to what extent NPD activities contribute to product advantage.

Song and Parry (1997) studied the extent to which the marketing and technical proficiency of NPD activities had an influence on product advantage. They expected that technical proficiency would increase product advantage by improving the actual performance of the product, whereas marketing proficiency was expected to increase consumer perceptions of product advantage. Survey data based on 788 NPD-projects from 404 Japanese firms confirmed their hypotheses. Thus, both marketing and technical proficiency during NPD are important for achieving product advantage.

Calantone and di Benedetto (1988) studied the combined effects of market intelligence and technical activities on product quality. Market intelligence referred to the availability of information on customers and competitors, whereas technical activities referred to the proficiency of certain development activities (such as initial screening, development and prototype testing). Based on data from 189 NPD projects in industrial firms it was found that both market intelligence and technical activities were positively related to product quality, which in turn was positively associated with new product performance.

Sethi (2000) investigated how new product quality is affected by team characteristics and contextual influences. Based on data from 141 NPD projects it was found that information integration and customers' influence on the product development process had a positive influence on product quality. However, product newness from the firm’s perspective was negatively related to new product quality. Interestingly, the negative effect of product newness on product quality was reduced when information integration increased. Thus, when NPD teams integrate information from other departments and share information with one another, it is possible to develop more innovative products without losing quality. Based on these findings, Sethi (2000) concluded that information integration may be critical throughout the NPD process.

Together, these findings suggest that market information processing and proficiency in NPD activities are both necessary to create product advantage. Thus, the conclusion from

the RBV that market information processing and NPD process proficiencies are theoretically both important sources for achieving competitive advantage is supported by empirical studies. This research project builds on these findings by investigating the effects of market information processing on achieving product advantage in different stages of the NPD process. To find out in which specific stage of NPD market information processing is most important, the next section reviews several NPD process models before presenting the generic three-stage model of NPD which is used in this research.

2.3 Representation of the NPD process

For organizing and structuring the NPD process, many different models have been prescribed in the literature (e.g., Cooper and Kleinschmidt 1988, Rosenau and Moran 1993, Urban and Hauser 1993). This section begins with a brief review of product development process models, then discusses the NPD process for different types of projects, and closes with a definition of three generic stages of product development (i.e., predevelopment, development, and commercialization).

2.3.1 NPD process models

The NPD process has been defined as 'a formal blueprint, roadmap, template, or thought process for driving a new product project from the idea stage through to market launch and beyond' (Cooper 1994, p.3). NPD process models have been developed to manage NPD projects and provide structure to NPD activities.

Many NPD process models exist and they often consist of a sequence of both diverging and converging steps (Roozenburg and Eekels 1998). For example, Cooper (1983) invented the Stage-Gate™ process for moving a new product from idea to launch. The Stage-Gate™ model divides the NPD process into a predetermined set of stages (or groups of cross-functional and often parallel activities) and gates (or decision points). The gates function as quality control checkpoints and are usually staffed by senior managers who own the resources required by the project team (Cooper 1990, Hart, Hultink, Tzokas and Commandeur 2003). In each stage of the process alternatives are generated (divergence), and at the gates a selection is made among them (convergence).

Table 2.2 presents a selection of NPD process models. Each model provides a detailed overview of the NPD process, with a varying number of stages. Early NPD process models tried to describe the product innovation process in a logical linear order. For example, one of the first NPD process models developed by Booz, Allen and Hamilton (1968) describes the NPD process as six consecutive stages where each stage is followed by an evaluation point that must be completed, before the next stage commences.

Table 2.2: Overview of different NPD-process models

Booz, Allen & Hamilton (1968)	**Buijs & Valkenburg (2004)**	**Cooper & Kleinschmidt (1986)**	**Crawford & Di Benedetto (2005)**	**Rosenau & Moran (1993)**	**Song and Montoya-Weiss (1998)**	**Ulrich and Eppinger (2004)**	**Urban & Hauser (1993)**	**Veryzer (1998)**
Exploration	Strategy formulation	Initial screening	Opportunity identification and selection	Concept phase	Strategic planning	Exploration	Opportunity identification	Dynamic Drifting Phase
Screening	Design brief formulation	Preliminary market assessment	Concept generation	Development phase	Idea development and screening	Concept development	Design	Convergence Phase
Business analysis	Product development	Preliminary technical assessment	Concept/Project evaluation	Design phase	Business and market opportunity analysis	System level design	Testing	Formulation Phase
Development	Implementation	Detailed market study/market research	Development	Manufacture/ launch phase	Technical development	Detail design	Introduction	Preliminary Design Phase
Testing	Product use	Business/ financial analysis	Launch		Product testing	Testing	Life cycle management	Evaluation Preparation Phase
Commercialization		Product development			Product commercialization	Production ramp-up		Formative Prototype Phase
		In-house product testing						Testing and Design Modification Phase
		Customer tests of products						Prototype and ‘Commercialization’ Phase
		Test market/ trial sell						
		Trial production						
		Pre-commercialization business analysis						
		Production start-up						
		Market launch						

More recent models also have a linear structure but they recognize that organizations may skip or iterate between activities and alter the process to their specific situation. For example, Urban and Hauser (1993) present the NPD decision process as a sequential set of activities. Although their model is sequential, the authors realize that organizations customize the process to their own needs and move back and forward between activities (Urban and Hauser 1993). Thus, over the years NPD process models have evolved from linear and sequential models towards integrated and iterative models with overlapping stages. As a result, NPD process models can be adapted more easily to different types of projects.

Several researchers have investigated to what extent development processes for radical innovations are different from those for incremental innovations. In case study research of eight radical innovation projects, Veryzer (1998) found that the early stages of radical innovation projects are more exploratory and less customer-driven than prescribed by conventional development process models (see table 2.2). Based on four case studies, Lynn, Morone and Paulson (1996) also concluded that the development process of radical innovations is different from the conventional process of incremental innovation. The radical innovation process is an iterative process where companies probe potential markets with immature versions of the product, learn from those probes and then try again in different market segments. O'Connor (1998) investigated the role that market learning played in radical innovation projects. Similar to Veryzer (1998) and Lynn et al. (1996), she found that formal and highly structured processes are less appropriate for radical innovations.

Song and Montoya-Weiss (1998) examined the differences between six NPD activities for 163 'really new' products and 169 incrementally new products. They found that improving the proficiency in business and market opportunity analysis was counterproductive for really new products, but had a positive impact on the profitability of minor innovations. Conversely, they found that the proficiency in strategic planning activities had a positive effect on the profitability of really new products, but a negative effect for incremental product innovations.

Thus, from these studies it appears that the NPD process for radical innovations differs from the NPD process for incremental innovations. Radical innovation projects are primarily driven by technology and use more informal approaches to understand customers and to get a general sense of the market.

When studying market information processing in high-tech NPD, it is desirable that NPD processes of different companies can be compared for all types of innovations. Existing process models with many stages as found in table 2.2 may be too fine-grained for our study of market information processing in high-tech NPD. For the purpose of this research project, it is therefore necessary to present a more generic NPD process model that all companies can relate to and that can be applied to different types of projects.

2.3.3 Generic stages of the NPD process

While the process models of table 2.2 organize NPD into four to thirteen stages, the NPD-process can be considered as consisting of a smaller number of stages, each with several activities, substages and decisions (Cooper and Kleinschmidt 1988, Hauser, Tellis and Griffin 2006). In their investigation of NPD-expenditures at various stages of the NPD process, Cooper and Kleinschmidt (1988) studied 13 commonly cited new product activities and divided the NPD process into three major stages: predevelopment activities (those activities from idea generation up to product development; the 'front end' of the process), product development and product testing (including in-house or lab tests and customer tests of the product; the middle of the process), and commercialization (including trial production, trial sell, production start-up, and market launch; the 'back end' of the process). More recently, the Product Development & Management Association (PDMA) has organized its Body of Knowledge (BOK) around the same three stages of product development including discovery (the front end), development (the middle), and commercialization (the back end). Following these thoughts, the present research organizes the NPD-process in three generic stages: predevelopment, development and commercialization. Table 2.3 shows how the more detailed NPD process models of table 2.2 can be grouped into our three stage model of NPD.

Predevelopment stage

The predevelopment stage is probably the most important phase of the NPD process as early decisions have a large impact on subsequent activities. In terms of the RBV, the predevelopment stage combines inside-out capabilities with outside-in capabilities as technology development and market assessment activities are performed concurrently. In support of this view, Zahay et al. (2004) found that customer account information, information about customer needs, information to aid in project management, regulatory information, information about competitors, strategic information, information pertaining to financial issues, and technical information all were used in predevelopment.

Several studies have shown that predevelopment activities have a positive influence on the performance of the final product (e.g., Cooper 1988, Langerak, Hultink and Robben 2004b). The predevelopment stage contains activities such as strategic planning, business and market opportunity analysis, and new product idea generation and evaluation (e.g., Crawford and di Benedetto 2005, Song and Montoya-Weiss 1998). In this initial stage, which is often called the 'fuzzy front end' of product innovation (Smith and Reinertsen 1992), new product ideas are transformed into new product concepts. The phase starts with an analysis of strategic directions and the identification of market opportunities. Furthermore,

technologies are explored in R&D laboratories. When technology is proven to work, attention turns towards finding potential product applications.

At this stage, market research may be necessary to gather information about customer needs and how the new product may impact those needs. Idea generation is often followed by a quick assessment of the market place and an initial technical inquiry of the ideas. Furthermore, a detailed market and business analysis could identify whether the project is commercially and financially feasible (Cooper and Kleinschmidt 1986). These activities should result in a business case that includes the product definition, the project justification, and a project plan (Cooper 2001). After this stage it should be clear which markets and customers the new product should aim for, and what the technical requirements will be (Rosenau and Moran 1993). The predevelopment stage ends with a list of formal product specifications that are used as input for the next stage: Development.

Development stage

Development starts when the business case has been approved (Cooper and Kleinschmidt 1986). During the development stage, attention turns toward converting product specifications into product designs that fulfill customer needs. In terms of the RBV, development is a typical spanning capability, which integrates the internal and external findings from the predevelopment stage into a new product. In the development stage, technical, project management and customer needs information have been identified as necessary to success (Zahay et al. 2004).

During the development stage, market research is needed to set product goals and make product feature trade-offs (Rosenau and Moran 1993). Feedback from customers can be used to verify that product specifications and features are still in alignment with customer needs. Testing back and forth with customers at this stage is integral to achieving product advantage, incorporating those features and benefits most valuable, and deleting those not providing customer utility. Thus, both internal and external information are used in this stage. The development stage is an expensive and lengthy stage because the actual design and building of the new product takes place, along with in-house and external testing of the product (Cooper and Kleinschmidt 1988). After validation of the product, this stage ends and the project is ready for commercialization.

Table 2.3: NPD process models in three generic stages

Booz, Allen & Hamilton (1968)	Buijs & Valkenburg (2004)	Cooper & Kleinschmidt (1986)	Crawford & Di Benedetto (2005)	Rosenau & Moran (1993)	Song and Montoya-Weiss (1998)	Ulrich and Eppinger (2004)	Urban & Hauser (1993)	Veryzer (1998)	Generic stages
Exploration	Strategy formulation	Initial screening	Opportunity identification and selection	Concept phase	Strategic planning	Exploration	Opportunity identification	Dynamic Drifting Phase	Predevelopment
Screening	Design brief formulation	Preliminary market assessment	Concept generation		Idea development and screening	Concept development		Convergence Phase	
Business analysis		Preliminary technical assessment	Concept/Project evaluation		Business and market opportunity analysis			Formulation Phase	
		Detailed market study/market research						Preliminary Design Phase	
		Business/ financial analysis						Evaluation Preparation Phase	
								Formative Prototype Phase	
Development	Product development	Product development	Development	Development phase	Technical development	System level design	Design	Testing and Design Modification Phase	Development
Testing		In-house product testing		Design phase	Product testing	Detail design	Testing	Prototype and 'Commercialization' Phase	
		Customer tests of products				Testing			
Commercialization	Implementation	Test market/ trial sell	Launch	Manufacture/ launch phase	Product commercialization	Production ramp-up	Introduction		Commercialization
	Product use	Trial production					Life cycle management		
		Pre-commercialization business analysis							
		Production start-up							
		Market launch							

Commercialization stage

In the commercialization stage, product specifications are released to manufacturing and the sales force is trained (Rosenau and Moran 1993). At this stage, manufacturing prepares for full-scale production and the new product starts to fill the pipeline (Cooper and Kleinschmidt 1986). Market introduction of the new product is prepared and decisions on launch strategies and tactics are made (Hultink et al. 1998).

Different types of market information may be needed during the commercialization stage. While Zahay et al. (2004) found that only customer account and project management information come into play in decision-making during commercialization, market research is needed for optimizing marketing communications, pricing and distribution decisions, and to get ready for the launch. After final testing, the new product is introduced into the market and market research activities may help determine whether the launched product is meeting its goals (Rosenau and Moran 1993).

Again, the activities in this stage can be explained with the resource-based view of the firm and the role of outside-in capabilities (Day 1994). During commercialization, market information is needed through outside-in capabilities to fine-tune the product to customer needs and to create a competitive advantage in the market place.

A generalized NPD process

The previous section has shown that many different models exist for describing NPD processes. Each model has its own merits and different models are needed for describing the NPD process for different types of innovations. Together, these models were combined in a general model of the NPD process with three major stages that are applicable across a range of firms and projects: predevelopment, development and commercialization.

Although many NPD process models have recognized the importance of a market-oriented NPD process, they have not provided much detail on how market information processing occurs. The next section reviews the available literature on market information processing in NPD.

2.4 Market information processing in NPD

The current section discusses how many previous studies have considered market information processing as the acquisition, dissemination and use of market information. Section 2.4.1 first defines market information. Then, section 2.4.2 summarizes the behavioral conceptualizations of a market orientation and shows how a behavioral market orientation can be described as a set of market information processing activities. Finally, section 2.4.3 provides an overview of studies that have investigated market information processing behaviors in NPD.

2.4.1 Defining market information

The term 'information' can be defined as data that has been placed in context and endowed with meaning (Glazer 1991). When information is narrowed down more specifically to *market* information, a useful taxonomy is provided by Dougherty (1990). Based on interviews with developers of new products, sixteen market information needs in NPD emerged that were classified in five dimensions: manufacturing, technology, business, customer needs and distribution. Firms that had information on most types of market information appeared to be more successful in their innovation efforts. In line with these findings, Slater and Narver (1995) plead for the broadening of the 'market' definition to encompass all sources of relevant knowledge and ideas pertaining to customers and customer value creating capabilities.

Similar to market information, Kohli and Jaworski (1990) use the term market intelligence. In field interviews with managers these authors found that market intelligence refers to customer needs and preferences, and includes an analysis of how those needs and preferences may be affected by exogenous factors such as government regulation, technology, competitors, and other environmental forces. Furthermore, the authors found that market intelligence pertains to both current and future customer needs, which is an important distinction for developing new products because a focus on current customer needs may lead to the development of new products that are less attractive to future customers (Christensen and Bower 1996).

Based on these findings, market information is defined here as information about both current and future customer needs as well as other environmental factors that may influence those needs. In this way, market information encompasses a broad market definition and differentiates between current and future customers.

2.4.2 Behavioral market orientation

Research has frequently conceptualized a market orientation as a set of organizational behaviors that refer to market information processing activities. For example, Shapiro (1988) refers to a market orientation as a decision-making process based on market information that is shared across every function in an organization. The current section shows how several studies have considered a market orientation as a set of market information processing activities at the firm level. This conceptualization of a market orientation with a market information processing perspective is defined here as behavioral market orientation.

Kohli and Jaworski (1990) refer to a market orientation as the implementation of the marketing concept. The authors identified the underlying components of a market orientation based on a review of the marketing literature and interviews with business scholars and 62 managers from U.S. industrial, consumer and service industries. These efforts showed that a market orientation consists of three market information processing behaviors at the firm level:

(1) the generation of market intelligence, (2) the dissemination of market intelligence across departments, and (3) the organization-wide responsiveness to market intelligence (See table 2.4). The first component, intelligence generation, refers to all activities undertaken by one or more departments to gather information about customers' current and future needs and factors that influence those needs. The dissemination of market intelligence describes how this information is communicated across departments to create a shared understanding. Finally, responsiveness refers to both response design (the use of market intelligence in planning) and implementation (execution of the plans) by the organization as a response to market information that has been gathered and shared (Kohli and Jaworski 1990). These behavioral components of a market orientation capture the essence of what Day (1994) calls a 'market sensing' capability that connects an organization to the external environment. The process of market sensing follows a similar sequence of information processing activities that organizations use to make sense of their markets. According to this view, a market orientation is an outside-in capability that should 'inform and guide both spanning and inside-out capabilities' (Day 1994, p.41).

Kohli, Jaworski and Kumar (1993) noticed a potential causal ordering among the three behavioral components of market orientation. Based on the work of Barabba and Zaltman (1991), the authors argue that there is a temporal structure among the acquisition, dissemination and responsiveness to market intelligence. This means that firms can not respond to market intelligence unless they have first disseminated and acquired it.

Table 2.4: Conceptualizations of a market orientation with an information processing perspective

Authors	**Kohli and Jaworski (1990)**	**Narver and Slater (1990)**	**Ruekert (1992)**
Components of a market orientation	Generation of market intelligence	Customer orientation	Obtaining and using information from customers
	Dissemination of market intelligence	Competitor orientation	Developing strategy to meet customer needs
	Responsiveness to market intelligence	Interfunctional Coordination	Implementing strategy to be responsive

Narver and Slater (1990) came up with three behavioral components of a market orientation: customer orientation, competitor orientation, and interfunctional coordination. Similar to Kohli and Jaworski (1990), the authors suggest that a market orientation consists of market information processing activities at the firm level. The three behavioral components of a market orientation have an implicit market information processing character. Both a customer and competitor orientation involve the activities for acquiring and disseminating market information throughout the organization. Subsequently, interfunctional coordination is

the mechanism for responding to market information through the coordinated creation of superior customer value. Thus, 'the behavioral components of a market orientation comprehend the activities of market information acquisition and dissemination and the coordinated creation of customer value' (Narver and Slater 1990, p.21).

Ruekert (1992) recognized that the conceptualizations of market orientation by Kohli and Jaworski (1990) and Narver and Slater (1990) share common characteristics as they are both concerned with market information processing behaviors and they both focus on obtaining and disseminating market information in order to create competitive advantage. Ruekert (1992, p.228) defines a market orientation as 'the degree to which a business unit (1) obtains and uses information from customers, (2) develops a strategy which will meet customer needs; and (3) implements that strategy by being responsive to customers needs and wants.' Thus, in this view, market-oriented organizations acquire and use customer information to develop and execute a customer focused strategy. Although this approach does not explicitly consider the dissemination of market information, it focuses on the collection and use of information in order to respond to customer needs and wants, and therefore, it also takes an implicit market information processing perspective.

To summarize, the behavioral conceptualizations of a market orientation have in common that they consist of market information processing activities at the firm level: generating, disseminating and using or responding to market information. Previous research also suggests that there may be a temporal order in the structure of these market information processing activities. Market information should be acquired, before dissemination and use can occur. To find out how these individual components of market information processing contribute to new product performance, the next section reviews the literature on market information processing in NPD.

2.4.3 Market information processing for NPD performance

Several studies have focused on market information processing as an important determinant of NPD performance. Moorman (1995) investigated to what extent organizational market information processes are related to new product outcomes. She distinguished between information acquisition, dissemination, instrumental use and conceptual use processes at the firm level. Instrumental use of market information refers to the direct application of market information in making, implementing and evaluating marketing strategy-related decisions. Conceptual use, on the other hand, refers to the indirect use of market information by recognizing the value of information or giving meaning to information (Moorman 1995). All organizational market information processes were expected to have a positive influence on new product performance.

Based on the responses from 92 marketing managers in advertising companies, Moorman (1995) found that the acquisition, dissemination and use of market information were positively correlated. Furthermore, only market information use was positively associated with new product performance suggesting that the effect of acquisition and dissemination processes on new product outcomes is mediated by the instrumental and conceptual use of market information. More recently, Citrin, Lee and McCulough (2007) investigated the relationships between the instrumental and conceptual use of information at the firm level and new product outcomes of high-tech firms. Based on data from 150 software development firms in India, the authors found that information use should be congruent with a firm's strategic orientation in order to innovate successfully.

So far, most studies have examined the components of market information processing at the firm level. Only a few researchers have investigated market information processing behaviors at the NPD project level. For example, Adams et al. (1998) conducted case-study research on 40 NPD projects in 15 large firms to find out which barriers hinder an organization's ability to learn about markets. The authors defined the market learning process of NPD as the acquisition, dissemination and use of market information and identified organizational learning barriers for each of these three sub-processes. Ottum and Moore (1997) studied the effects of market information processing behaviors in NPD on new product performance. The authors conceptualized market information processing in NPD as the amount of gathering, sharing and using of market information in a specific NPD project. Market information referred to information about the overall size of the market, specific customer needs and wants, and characteristics of market segments. Based on survey-data from multiple respondents (marketing, R&D and manufacturing) in 58 NPD projects it was found that the use of market information was the only significant predictor variable of NPD success. In addition, the authors constructed a multiple equation regression model and found that information use was most strongly related to the amount of information shared, which in turn was a function of the amount of information gathered. Thus, their findings indicate that the effects of information gathering and sharing on new product performance are mediated by the use of market information in the NPD process.

Salomo, Steinhoff and Trommsdorff (2003) proposed a conceptualization of customer orientation at the project level based on information processing activities in the NPD process. The authors studied the effects of customer intelligence generation, dissemination and responsiveness in innovation projects on new product performance. The generation of customer intelligence was operationalized as customer research activities, customer intelligence dissemination as the integration of customers, and responsiveness as market preparation and launch activities in the NPD process. Based on data from 103 product innovation projects in German industrial companies, it was found that the dissemination of

customer intelligence and the integration of customers in development was positively related to technical performance. Furthermore, there was some support that the effects of information generation and dissemination on new product performance increased with the degree of product innovativeness.

To summarize, several studies have focused on some of the details of how market information is processed at the firm level and at the NPD project level, but none has investigated how it is processed in the different stages of NPD. Similar to the behavioral market orientation literature, the market information processing literature suggests that the overall construct of market information processing consists of three main tasks: acquiring information, disseminating it, and finally using the information. Moreover, these studies indicate the importance of market information processing in NPD to achieve success. Despite its importance, market information processing in NPD may be difficult to achieve and is often missing in NPD (e.g., Adams et al. 1998, Cooper et al. 2004a, Griffin and Hauser 1996, Maltz and Kohli 1996, Ottum and Moore 1997). The problems with market information processing in high-tech NPD have been described earlier in chapter 1. The next section reviews the literature on the antecedents of market information processing to find out how market information processing in NPD can be enhanced.

2.5 Antecedents of market information processing in NPD

Previous studies have shown that several structural and cultural characteristics of an organization may influence various aspects of market information processing (i.e., acquiring, disseminating and using market information). The current section summarizes the main findings from these studies and concludes with an overview of structural antecedents (formalization, centralization and interdepartmental conflict) and cultural antecedents (market orientation, entrepreneurial orientation and willingness to cannibalize) to market information processing.

2.5.1 Structural antecedents of market information processing

Previous research suggests that several market information processing variables may be affected by how an organization is structured. For example, studies on the use of market information and the flow of information between R&D and marketing have shown that structural characteristics of an organization influence using and disseminating market information (e.g., Deshpandé and Zaltman 1982, 1987, Gupta and Wilemon 1988, Moorman et al. 1993, Ruekert and Walker 1987). In addition, the characteristics of an organizational structure have been investigated extensively in the market orientation literature for their possible effects on market-oriented behaviors (acquiring, disseminating and responding to market information) (e.g., Jaworski and Kohli 1993, Kirca, Jayachandran and Bearden 2005).

Together, these studies have shown that *formalization*, *centralization* and *interdepartmental conflict* may be related to the acquisition, dissemination and use of market information.

Structural antecedents for the use of market information

Several studies have demonstrated that different aspects of the organizational structure are related to the use of market information. For example, Deshpandé and Zaltman (1982) found that *formalization* and *centralization* were both negatively associated with the use of market research information by marketing managers in consumer good firms. Formalization refers to the degree to which rules define roles, authority, relations, communications, norms and sanctions and procedures. Centralization is defined as the delegation of decision making authority throughout an organization and the participation of managers in decision making. Deshpandé and Zaltman (1987) studied these company structural characteristics for their potential influence on the use of market information by marketing managers in industrial firms (instead of consumer good firms). They found that a formalized organizational structure was positively related to market information use, and that centralization was not related to the use of market information.

A third characteristic of an organizational structure that has been studied as a potential antecedent of market information use is *interdepartmental conflict* that is defined as the tension between departments that arises from having divergent goals and a functional rather than an organizational perspective. Maltz, Souder and Kumar (2001) investigated the relationship between inter-functional rivalry and the use of market information by R&D managers. The authors expected that inter-functional rivalry would be negatively related to market information use. When rivalry is high, R&D managers may be likely to ignore information from marketing to reduce the likelihood that the marketing department can show its value to the firm. Based on the responses from 718 informants (manufacturing, R&D and finance) in 265 organizations, the authors found a strong negative effect of inter-functional rivalry on market information use by R&D managers.

To summarize, three structural characteristics of an organization have been investigated for their potential influence on market information use: formalization, centralization and interdepartmental conflict. The direction of the relationships for formalization and centralization may depend on the business context (negatively for consumer goods and positively or not at all for industrial products). Furthermore, the use of market information is negatively related to interdepartmental conflict.

Structural antecedents for the dissemination of market information

Several studies on the R&D-marketing interface have examined how company structural characteristics affect the dissemination of market information. For example, Gupta and

Wilemon (1988b) investigated the relationships between company structural characteristics and the degree of cooperation and information sharing between R&D and marketing personnel in the NPD process. Based on the results of a survey of R&D managers from 80 high-technology companies, it was found that formalization was positively associated with the degree of information sharing between R&D and marketing. Centralization, on the other hand, was negatively related to information sharing.

In an exploratory study of the interaction between marketing and R&D personnel, Moenaert and Souder (1990b) found that respondents blamed the lack of formalization for the inadequate information transfer between the two functions. Based on the responses of marketing and R&D managers of 78 innovation projects in 40 Belgian firms, Moenaert, Souder, De Meyer and Deschoolmeester (1994) found that formalization was positively related and centralization negatively related to cross-functional communication.

Ruekert and Walker (1987) investigated to what extent formalized interactions and interdepartmental conflict are related to the interaction between marketing personnel and personnel in other functional areas. Based on the responses from 95 marketing employees and 56 non-marketing employees, they found that formalization is positively related and interdepartmental conflict negatively related to the effectiveness of interactions between different functions.

To summarize, previous studies found that formalization has a positive influence on communication and information sharing, whereas centralization and interdepartmental conflict have negative effects. Together, these findings indicate that a formalized structure may stimulate the dissemination of market information through better communication. On the other hand, centralization and interdepartmental conflict may be detrimental to the dissemination of market information because they both inhibit communication across departments.

Structural antecedents for the acquisition of market information

Although the determinants of market information dissemination and use have been studied widely, studies on the antecedents of market information acquisition are rare. Only the market orientation literature has implicitly dealt with antecedents to the acquisition of market information as part of the behavioral market orientation construct (Kohli and Jaworski 1990, Jaworski and Kohli 1993).

Kohli and Jaworski (1990) proposed that formalization and centralization are organizational systems that could make organizations less adaptive to the marketplace. Interdepartmental conflict was expected to inhibit the communications that are necessary for effective market sensing. However, the authors did not hypothesize a relationship between interdepartmental conflict and market information acquisition.

Jaworski and Kohli (1993) used two samples for testing their original hypotheses. Sample one consisted of marketing and non-marketing informants from 222 business units that were member companies of the Marketing Science Institute and top 1000 companies listed in Dun and Bradstreet's Million Dollar Directory. Sample two, for cross-validating the findings, used informants from the American Marketing Association membership list and resulted in 230 responses.

Contrary to their hypothesis, formalization was not related to the acquisition of market information. In line with their original expectations, centralization of decision-making served as a barrier to market-oriented behaviors. However, the results for the two samples were different. In the first sample, centralization was negatively related to intelligence dissemination and responsiveness and in the second sample centralization was negatively related to the acquisition of market information. This finding suggests that for the acquisition of market information it may be useful to decentralize and 'empower' employees to make decisions at lower levels of the organization (Jaworski and Kohli 1993).

To summarize, the literature review identified three structural antecedents of market information processing: formalization, centralization and interdepartmental conflict. These antecedents have previously been related to the individual components of market information processing. Formalization was found to be positively related to the dissemination and use of market information. Centralization may be detrimental to all market information processing variables, but findings for the use of market information are inconsistent across different business contexts. Finally, previous studies suggest that interdepartmental conflict is negatively related to disseminating and using market information. Together, these three structural antecedents will be taken into account for their influence on all market information processing components in the different stages of the high-tech NPD process.

2.5.2 Cultural antecedents of market information processing

Although previous research has mainly focused on the structural antecedents of market information processing, other studies suggest that market information processing is also influenced by an organization's culture (Moorman 1995, Slater and Narver 1995). For example, Moorman (1995) investigated market information processes and found that the use of market information is a 'people process' that is influenced by the culture of an organization. More specifically, she found that clan cultures which are informal and internally oriented, dominate other cultures in influencing market information processing. Thus, organizational culture may be an important antecedent of market information processing.

Organizational culture is defined as 'the pattern of shared values and beliefs that help individuals understand organizational functioning and thus provide them with the norms for behavior in the organization' (Deshpandé and Webster 1989, p.4). Through this pattern of

shared values and beliefs, organizational culture may influence behaviors in the context of market information processing and NPD.

Based on the marketing literature and the literature on radical innovations (e.g., Atuahene-Gima and Ko 2001, Chandy and Tellis 1998, Slater and Narver 1995), three characteristics of an organization's culture are investigated in this research: market orientation, entrepreneurial orientation and willingness to cannibalize.

According to Atuahene-Gima and Ko (2001), market and entrepreneurial orientations have an effect on how organizational members process information and react to the environment and lead to congruent behaviors at the NPD team level. Therefore, a market orientation and entrepreneurial orientation at the company level are considered for their potential influence on market information processing behaviors at the NPD project level.

The literature on radical innovations identified a third cultural antecedent: a company's *willingness to cannibalize* that refers to a company's willingness to replace existing operating systems and products in the interest of the introduction of new products (Chandy and Tellis 1998). Although willingness to cannibalize has been identified as an important variable for radical innovation (Chandy and Tellis 1998), it has not yet been studied in the context of market information processing. However, willingness to cannibalize is an important variable for high-tech NPD that may also influence market information processing: If firms are willing to cannibalize on past investments they need to process market information before making new investments. Therefore, this research considers a company's willingness to cannibalize as a cultural antecedent of market information processing for high-tech products. In the remainder, the literature on the relationships between market information processing and these three cultural antecedents will be summarized.

Cultural market orientation

Market orientation has been studied from both a cultural and a behavioral perspective. Whereas the behavioral perspective describes market orientation in terms of specific behaviors, the cultural perspective is related to more fundamental characteristics of the organization. According to the cultural perspective, a market orientation culture leads to the market oriented behaviors of acquiring, disseminating and responding to market information (which in this thesis is referred to as market information processing).

Homburg and Pflesser (2000) empirically investigated the relationships between a cultural market orientation and market oriented behaviors. Based on a survey of 160 key informants in five different German industries, the authors conclude that both market oriented values and norms have indirect effects on market oriented behaviors (generating, disseminating and responding to market intelligence) through market oriented artifacts, additional components of organizational culture. These findings suggest that a market

oriented culture at the company level may lead to market information processing behaviors at the project level.

Cultural market orientation is an important antecedent of product innovation as it creates behaviors that focus on understanding the articulated needs of customers (Atuahene-Gima and Ko 2001). Several studies have shown that a cultural market orientation at the company level is related to innovation and market information processing activities at the NPD project level (e.g., Gotteland and Boulé 2006, Kirca et al. 2005). For example, Atuahene-Gima (1996) found that a market orientation was positively associated with innovation-marketing fit, product advantage, and interfunctional teamwork. In an earlier study Atuahene-Gima (1995) showed that a market orientation had a strong effect on the proficiency of predevelopment activity, proficiency of launch activity, service quality, product advantage, marketing synergy, and teamwork. More recently, Langerak et al. (2004a) found that a market orientation at the company level had a positive and significant effect on NPD launch activities and product advantage. Based on the responses from 142 product managers and sales directors in 58 French industrial sectors, Gotteland and Boulé (2006) found that a customer orientation was positively related to the instrumental use of market information in NPD. Together, these findings suggest that a cultural market orientation at the company level leads to market oriented behaviors at the NPD project level. If a cultural market orientation is shared by all members of an organization, then a development team will likely acquire, disseminate and use more market information during an NPD project.

Entrepreneurial orientation

It has been suggested that a market orientation should be combined with an entrepreneurial orientation to encourage a sufficient willingness to take risks and to ensure a proactive and aggressive focus on innovations that meet emerging and unarticulated customer needs (Atuahene-Gima and Ko 2001, Slater and Narver 1995). For example, Atuahene-Gima and Ko (2001, p.57) recommend that besides a market orientation, companies need an entrepreneurial orientation in order to 'have a better knowledge of their current and future customers, competitors and other environmental conditions, and thus have greater overall adaptive and environmental management capability in meeting customer needs.'

Entrepreneurial orientation refers to an organization's attitude towards entrepreneurial processes characterized by its preferences for innovativeness, risk taking and proactiveness (Matsuno, Mentzer and Ozsomer 2002). Together, these three dimensions facilitate organizational members' willingness and ability to engage in market intelligence activities and responsiveness, thus promoting a behavioral market orientation. An innovative culture has been argued to promote information sharing and information use (Menon and Varadarajan 1992). A willingness to take risks may stimulate market information processing

to discover emerging and unarticulated customer needs (Atuahene-Gima and Ko 2001). Proactiveness refers to a forward looking perspective which promotes finding new market opportunities and acting on those opportunities (Matsuno et al. 2002). In other words, an entrepreneurial orientation may stimulate market information processing activities because of the innovativeness, proactiveness and willingness to take risk.

Matsuno et al. (2002) empirically investigated the effects of an entrepreneurial orientation on a behavioral market orientation. They tested their conceptual framework with 364 market executives in US manufacturing companies and found that an entrepreneurial orientation has a direct impact on acquiring, disseminating, and responding to market intelligence. These findings suggest that an entrepreneurial orientation may also be related to market information processing behaviors at the NPD project level.

Willingness to cannibalize

Willingness to cannibalize refers to the extent to which firms are prepared to give up the old and embrace the new, and to which a firm is prepared to reduce the value of past investments (Chandy and Tellis 1998). Therefore, willingness to cannibalize is an attitudinal trait and resides in the culture, or shared values and beliefs, of a firm (Chandy and Tellis 1998). Chandy and Tellis (1998) showed that this concept is a key variable for explaining why some companies develop more radically new products than others.

Firms that dominate markets often are reluctant to embrace radical innovations. One reason for this reluctance comes from the fact that these firms have specialized investments in the form of assets and organizational routines with which they serve their current markets. If an organization switches to a new technology supporting a radical innovation, its specialized investments in old technologies could become obsolete (Chandy and Tellis 1998). Christensen (1997) described this problem in his book '*The Innovator's Dilemma*' and showed how disruptive technologies may lead to the failure of leading firms if they stick to their current technologies. In contrast, firms that are willing to cannibalize their past investments will allocate adequate resources to radical product innovation. Chandy and Tellis (1998) found that in certain situations cannibalization is a desirable trait that can promote radical product innovation. Based on a survey of 504 business units in high-tech industries the authors found that a firm's willingness to cannibalize is positively related to the market introduction of radical product innovations.

If firms are more willing to cannibalize past investments they may be more sensitive to market developments in order to find new market opportunities. In addition, firms that are willing to cannibalize, may actively search for market information and try to find new customers and new markets for their new technologies. Although willingness to cannibalize has not been investigated in the context of market information processing, it can be expected

that companies that are willing to cannibalize their past investments will gather, disseminate and use more market information while developing new high-tech products.

2.6 Summary and conclusions

This chapter reviewed the literature to identify potential antecedents and consequences of market information processing in high-tech NPD. The chapter defined two outcomes of market information processing: product advantage and new product performance. First, the importance of new product performance for the survival and growth of companies was explained. The example of Apple's iPod in Exhibit 2.1 showed how NPD may be beneficial to company sales and stock market value. Second, product advantage was identified as an important driver of NPD performance. Findings from two meta-studies on new product performance (summarized in table 2.1) confirmed this leading role of product advantage. Furthermore, it was posited that product advantage may be an important mediating variable between market information processing and new product performance. The RBV was used to explain how companies achieve product advantage. Market information processing was considered an outside-in capability that can be implemented in NPD, as a spanning capability, to create competitive advantage. Based on this theory and the findings from empirical studies, chapter 2 concluded that product advantage can be considered a consequence of market information processing in NPD.

To investigate in which stage of NPD market information processing is most important the chapter continued with a review of NPD process models. Although each model has its own benefits, none of the NPD process models provided sufficient detail on market information processing in NPD. Furthermore, most of the models were too fine-grained for the study of market information processing. Therefore, a generic three stage model of NPD with a predevelopment, development and commercialization stage was presented.

Based on the behavioral market orientation literature, the chapter posited a market information processing model for NPD that distinguishes between the acquisition, dissemination and use of market information. Research suggests that these variables should be studied separately as there may be a temporal order between them.

Finally, the chapter identified six antecedents of market information processing: three structural antecedents (formalization, centralization, and interdepartmental conflict) and three cultural antecedents (cultural market orientation, entrepreneurial orientation and willingness to cannibalize). To identify additional antecedents of market information processing in high-tech NPD, the next chapter investigates market information processing in firms using exploratory interviews and a case-study with practitioners.

Chapter 3 - Exploring market information processing with practitioners

This chapter presents the results from 11 exploratory interviews with NPD managers in different firms and a case study based on data from interviews with eight managers in a single firm. In the exploratory interviews (section 3.1) the role of market information processing is investigated in different high-tech NPD projects. The projects range from visual inspection systems to mobile phones in business-to-business and business-to-consumer markets. The case study (section 3.2) describes the development process of the first car navigation system for the European market. The case study shows why market information processing may be problematic for high-tech NPD and how one organization dealt with these hurdles in implementing market information in its new product. While the previous chapter presented company structural and company cultural antecedents of market information processing as revealed through the extant literature, the interviews with practitioners and the case study revealed a new set of antecedents related to project urgency characteristics (project priority and time pressure) and one additional cultural antecedent (R&D dominance).

3.1 Exploratory interviews with practitioners

A qualitative research approach was used to show how market information is processed in high-tech NPD and how this may be influenced by different organizational settings. For this qualitative research, exploratory interviews with employees involved in the development process of new high-tech products were conducted. In total, 11 interviews were conducted in nine Dutch and two Belgian companies that develop high-tech products. Two companies operate in the service industry (Internet and mobile telecommunications) while the other nine are manufacturing companies. Four of the manufacturing firms produce consumer products (web pads for home communication, mobile phones, car navigation systems and video-glasses). The other five manufacturing firms produce products for industrial markets (industrial machinery, identification systems, telecommunications systems, visual inspection systems for test-tubes and semiconductor industry). Table 3.1 provides a short summary and appendix 1 a fuller synopsis of each of the firms. Because of confidentiality reasons, the real names of the companies have been disguised.

Companies were asked to participate in this research if they had a track-record of developing and commercializing high-tech products or if they had received media coverage for a recently introduced high-tech product. Companies that had developed recent high-tech products were asked to select their most innovative NPD project that was recently introduced. The NPD project level was chosen as the unit of analysis because it provides a good vehicle for the study of market information processing in NPD (Moenaert and Souder

1990a). Single informants who were knowledgeable about the selected NPD project were identified in each company. In two companies it was possible to find two informants who both participated in the same interview. Because the objective of this study was exploratory, people from different functional areas were interviewed to obtain diverse views on the topic. The respondents were professionals in the field of marketing, R&D, design, business development, and general management.

Table 3.1: Overview of companies, products and respondents in the exploratory interviews

Company	**Selected products**	**Target market**	**Function of interviewees**	**Number of persons**
Consumer Electro Co.	Video glasses for cinematic experience	B-to-C	New business development manager	1
Mobile Communications Inc.	Mobile phones for 3G Mobile Network	B-to-C	Product marketing manager	1
Mobile Services Inc.	Services for 3G Mobile Network	B-to-C	Market researcher	2
Nordic Telecom Inc.	Web pad device for home communication	B-to-C	Design coordinator strategic marketing	1
Smartagent.com	Internet-based software agents	B-to-C	Lead designer and Financial officer	2
Car Communications Inc.	Car navigation system	B-to-B/ B-to-C	Manager hardware development	1
Biometric ID	Authentication system for Internet transactions	B-to-B	Project manager R&D	1
Embedded Electro Co.	Automatic telecom dialler	B-to-B	R&D manager	1
Thermo Technology Inc.	Anti-theft smoke machine	B-to-B	General manager	1
Vision Equipment Inc.	Visual inspection systems for semiconductor industry	B-to-B	Marketing manager	1
Visual Machinery Inc.	Visual inspection system for test-tubes	B-to-B	General manager	1

The interview instrument consisted of a series of interview topics that focused on (1) the organization, (2) the respondent's role in the NPD project, (3) the NPD process, (4) the acquisition and characteristics of information, (5) the storage and dissemination of information and (6) the use of market information. The full set of questions can be found in Appendix 2. The interviews used open-ended questions. In this manner, the interviews were semi-structured and respondents could elaborate on the diverse topics. For example, the interviews asked respondents to think about the selected NPD project and the market information that was needed during the project. The interviews, which were tape recorded and transcribed, were between one and two hours in length. Additional information in the form of financial reports and internal documents were collected whenever possible. For the analysis across interviews, the transcribed interview texts were compared systematically. First, the topics from the interview checklist were used as a reference point to analyze the interview data. Then, each interview was summarized and notable characteristics of the

projects and the companies were labelled. When a characteristic was found in one interview, the other interviews were cross-checked to investigate whether it appeared in other situations as well. The resulting characteristics were discussed with a second researcher, who was an expert in the field of new product marketing, to decide if they could be relevant for market information processing in high-tech NPD.

Analyzing the interview texts suggested that several market information processing variables (acquisition, dissemination and use of market information) were interrelated and that three potential antecedents recurred systematically across the interviews: project priority, time pressure and R&D dominance. First, the findings for the market information processing variables are presented, followed by a discussion of the potential antecedents of market information processing during high-tech NPD.

3.1.1 Findings for the market information processing variables

The first set of results from the exploratory interviews is about the acquisition, dissemination, and use of market information. The findings reveal specific problems of market information processing for high-tech products and they show how some companies dealt with these hurdles. Furthermore, the findings recognized interrelationships between the acquisition, dissemination, and use of market information.

Acquisition of market information

One major problem with regard to the acquisition of market information for high-tech products is that it may be difficult for customers to tell in advance what they think about a new product. For example, one interviewee from an Internet-start up company explained that '*People can hardly say what they will do with something new and are very bad in predicting their own behavior. It is difficult to ask people whether they are going to use something or not'* (Interviewee Smartagent.com). This example shows that it is sometimes difficult to determine which type of research is necessary at which stage of the development process. Traditional market research techniques may result in information about customers' current needs and wants whereas methods like empathic design, lead user analysis and information acceleration (Burns, Barett and Evans 1999, Moorman et al. 1993, Urban, Weinberg and Hauser 1997, Von Hippel 1986) may reveal unsolved problems and discover latent needs. Therefore, the information that results from these non-traditional methods may be more useful for the development of high-tech products. One interviewee implicitly referred to outcome-based interviews (Ulwick 2002) when he described the type of questions that he asked in high-tech consumer research: '*If you ask consumers to sketch a television that they want to have next year, it will definitely go wrong. People can't even draw a bicycle. Thus, you should not ask that. Instead, you should ask what they think is important in a bicycle. But*

you should not ask them to design their own bicycle, you should ask them what they plan to do with it.' (Interviewee Consumer Electro Co.)

Qualitative information about customers' needs and wants is useful in the early stages of the development of high-tech products, but it was sometimes difficult to interpret and often considered unreliable. Senior management preferred to use 'hard' quantitative information on, for example, market growth and customer preferences to decide whether to move on, or kill a project. Management also wanted to know with high confidence levels how the market would react to the product and why competing firms were not successful. In general, the problem with developing high-tech products that don't exist yet was to convince management that there is a potential market: '*If I can say exactly how many products will be sold, at what price and by whom, management will continue with the project. But how much do you want to invest to get this information and is it available at all?*' (Interviewee Consumer Electro Co.)

Different methods were used by the companies to deal with these problems and acquire information about the market. Companies in industrial markets talked to customers individually, whereas companies in consumer markets used surveys, interviews, focus groups, concept tests and usability tests to understand customers. In several cases, market information was acquired from trend-watchers and research institutes like Forrester and Jupiter in the early stages of development. The interviews showed that some companies used customer helpdesks to provide technical assistance for their products. These helpdesks were an important source of market information and they provided product developers with invaluable information about the product in use.

<u>Dissemination and use of market information</u>

The interviews revealed several problems with regard to the dissemination of market information. In some companies it was found that market researchers and product managers decided which information would (or would not) reach the development team. For example, the design coordinator at Nordic Telecom explained that some team members in his company would not get access to an electronic webpage with market research studies: '*Not everyone has access to that and we have a vision about this. If you give access to everybody they will probably start surfing the Internet all day. Some people just have to work on things, otherwise that won't happen.*' Obviously, this procedure resulted in less accessible information that did not help the dissemination of market information.

In one of the interviews, it was found that dissemination of market information occurred only through the communication between a marketing manager and a project manager who was the spokesperson of the R&D department. In this company, R&D and marketing personnel could not communicate effectively with each other. The different

functions lived in their own thought-worlds and spoke their own languages. These barriers between functional areas distorted the dissemination of market information and resulted in a situation where not all relevant market information could be used.

Interrelationships between market information processing variables

The findings from the exploratory interviews indicate several interrelationships between the acquisition, dissemination, and use of market information. For example, in an interview with internal market researchers some of these interrelationships were mentioned. The market researchers noticed that market information was sometimes not used, because product managers found the conclusions of market research hard to believe. Several solutions with regard to the dissemination of market information were found to this problem. Market researchers increased the use of market information by giving the video-tapes of interviews with customers to the product managers, by inserting consumer-quotes into the reports and presentations, and by inviting the product managers behind the mirror-window of the interview room to look over-the-shoulder of the interviewer. The video-tapes and the over-the-shoulder technique prevented the users of market information from saying 'Did the customers really say that' or 'I don't believe customers think like that'. Thus, by disseminating the information directly to decision makers, the market researchers increased the use of market information. According to the interviewees, the best way to increase the use of market information was to involve the users of the market information in the design and execution of the market research.

Several observations indicated a relationship between the acquisition of market information and the actual use of market information. For example, during the development project of the video glasses at Consumer Electro Co. results of market research were often 'inconclusive' and could not be used for decision-making. Consumers sometimes gave conflicting information because they had different applications in mind. This inconsistency of consumer evaluations could be explained by the type of market research that was used for the acquisition of market information. Early market studies were conducted at the product-level by showing pictures of potential applications during concept screening. Later studies focused more on emotional benefits such as relaxation and pleasure instead of actual product applications. The findings from these later studies could be used as new product applications were defined based on these emotional benefits. Thus, in this company the acquisition of market information affected whether market information was used or not.

A third observation about the interrelationships between market information processing variables referred to the storage of information in customer databases. Several companies used customer helpdesks as an important source of market information. In one company this helpdesk information was stored in a customer database. Personnel from the

R&D department had access to this information and added their product-ideas to the customer database. At a certain point in the development process these inputs were combined and the market information was used by implementing it in a new product.

Together, these findings suggest that reliable market information should be acquired before dissemination and use can occur. This provides some evidence for the temporal structure of market information processing. First, the right information should be acquired and presented in a useful way. Then, the information should be made accessible to organizational members to enhance its use.

3.1.2 Findings for the antecedents of market information processing

An important goal of the exploratory interviews was to identify additional antecedents of market information processing for high-tech products. Based on the interview data it was found that the priority given to an NPD project, the time pressure felt during a project and R&D dominance were important factors influencing market information processing in high-tech NPD. Project priority and time pressure are labelled as project urgency variables and R&D dominance is considered an additional characteristic of a company's culture.

Project priority

The priority given to a project can influence whether NPD decisions are based on market information. Several interviewees indicated that when a project is of high importance to the company, more attention is paid to market information processing in the different stages of the development process. In addition, higher project priority leads to a greater allocation of resources to market research.

Low project priority may lead to less market information processing. For example, one interviewee from the company Thermo Technology Inc. explained that their NPD project became less important than existing businesses because that was where the current money came from. Their self-initiated NPD project moved to the background because other projects for existing customers were considered more important. In this case, market information was acquired in infrequent batches because of the low priority of the NPD project. Furthermore, the project cycle-time increased to almost two and a half years instead of one year, because the project was considered less important than other projects. Therefore, lower project priority is expected to decrease market information processing and to increase cycle time.

Market information processing may also be necessary for verifying a project's priority. For example, market researchers from Mobile Services Inc. explained how they sometimes had to gather market information to find out whether the importance of a project was defensible. In one case, business development initiated a new mobile service development project based on findings from trend researchers such as Forrester and Jupiter. Early trend

reports identified a large potential market. However, this new service could be considered risky from a user's point of view because it contained the application of a new technology for localization purposes. Although the project received a high status within the organization from the start, consumers could reject the technology because it might reveal private information. Therefore, the market researchers were asked to find out how consumers would experience this new service and to find out whether the project's priority was justified.

Together, these findings suggest that project priority is positively related to market information processing. High project priority increases the importance of market information processing and leads to a larger allocation of resources to market research. Low project priority, on the other hand, reduces the amount of market information processing as the project is considered less important.

Time pressure

Time pressure is defined as the extent to which team members believe that they have a shortage of time during a specific NPD project (Sethi 2000). During high-tech NPD projects, time pressure is a common complaint that may inhibit market information processing.

An interviewee from Consumer Electro Co. explained that time pressure was becoming more important in their markets because product life cycles were getting shorter. Furthermore, the company's new CEO focused on short payback periods. If a new product wasn't going to be profitable within two years, the company stopped pouring further money into the project. Time pressure also played a major role in the industry for visual inspection systems. A general manager from Visual Machinery Inc. mentioned that their products were changing continuously. This quick change was caused by fast developments in the semiconductor industry where the processing power of computer chips increases almost every month. According to the interviewee, *'You have to take that into account while developing new products, you can't stop it, because it's an external factor.'* Also in the telecommunications industry time-to-market and being on time are important as mobile networks evolve continuously and mobile phones are replaced almost every year. According to our interviewee at Mobile Communications Inc. high time pressures may be detrimental to market information processing: *'Although market information is important, sometimes we have to compromise between doing market research and taking decisions, because we are dealing with fairly short product life cycles.'*

In the interview with the market researcher from Mobile Services Inc., it was found that time pressure influenced market information processing in two ways. In this company, market research was proactively conducted by the market research department to identify latent market needs and develop new product concepts. Sometimes, the results from market research were not used by product managers and business development managers because

they were too busy with their daily jobs. Market information from the market research department was just one of the sources of information for making decisions in product development. While product managers were working on current projects they were not always waiting for market research about future product concepts. Sales targets for current products had to be reached; thus there was no time to use market information for starting new product directions that market research initiated. When asked about the use of market information, one market researcher replied: *'They [business development] prefer to not always use the information, because they don't have time for everything. We may have very nice ideas, but they are also busy with their daily jobs.'*

Secondly, time pressure also affected the acquisition process of market information within Mobile Services Inc. The market research department initiated their own research projects that were not accompanied by much time pressure. For these projects, there was enough time for conducting interviews and talking to consumers because there were no strict deadlines. For other projects, with a strict deadline and a short time frame, market researchers chose to use focus group sessions because this technique was more time-efficient than conducting individual interviews. According to the market researchers, time pressure caused by business development influenced the research design for the acquisition of market information: *'In six weeks, there is not so much time, and therefore we chose to do a focus-group session. We had to take the planning of the business into account, because they wanted to take a decision at a certain moment.'*

Taking everything into account, it is reasonable to expect that high levels of time pressure lead to less processing of market information by NPD-personnel. When time pressure is high, less time can be spent on the acquisition, dissemination and use of market information during NPD-projects.

R&D dominance

In high-tech firms, R&D often dominates marketing in influencing NPD decisions (Workman 1993). Findings from the interviews indicated that an engineering-driven culture can be an impediment to effective market information processing as engineers tend to discount the utility of market information compared to technical information. Product managers with a technical background, engineers in management teams and a large number of technical employees indicate R&D functional dominance. Too much R&D dominance may lead to a strong belief in the importance of the technical superiority of the product, and to a lower allocation of resources to market research to understand the problems that technical superiority is there to solve.

In the interviews with most industrial companies it was found that these companies consist of many technical employees that do not conduct much formalized market research.

Engineers interacted directly with customers to build customized products and that's how they get an understanding of the market. Furthermore, NPD in these industries was often driven by technological possibilities. At Mobile Communications Inc., for example, the third generation mobile network (UMTS) was becoming the next technological standard and new mobile phones had to be adapted to this network. Although the company conducted a lot of market research, many product features were ultimately determined by technological possibilities. An interviewee at Nordic Telecom explained that technical employees do not take the user's viewpoint, but start with the technology: *'If product management has certain ideas about the market and presents them to R&D, they [R&D] often say that it is not technically possible to work it out.'*

One incident where R&D dominance resulted in less effective market information processing was vividly explained by a market researcher from Mobile Services Inc. In this case, the results from market research were presented to the technical project leader of a new mobile service platform, but this person did not want to accept the outcomes of the study. The project leader was thinking of a different technological platform, and could not use this specific market information for that purpose. Moreover, the project leader asked someone else from R&D to falsify the results which showed that what marketing proposed was technically unfeasible. Thus, the market researcher concluded that '*not every setting is appropriate for telling nice stories about consumers.*'

3.1.3 Conclusions

The objective of the exploratory interviews with practitioners was to identify additional antecedents of market information processing in high-tech NPD. Based on 11 interviews with NPD managers in different firms it was found that the acquisition and dissemination of market information were both important variables for the use of market information, providing some support to the temporal structure of market information processing. Furthermore, the interviews identified project priority, time pressure and R&D dominance as potential antecedents of market information processing. Findings from the interviews indicated that a higher project priority was accompanied by more market information processing in different stages of NPD. On the other hand, time pressure and R&D dominance were listed as factors that could decrease market information processing. To study market information processing and its antecedents in high-tech NPD in more detail, the next section presents the findings of a case study on the development of a car navigation system.

3.2 Case study: Market information processing in a car navigation system project

This case study describes the development process of a car navigation system based on interviews with eight managers within a single firm. The case study involves the development

of three generations of car navigation systems, starting from the first vision of car navigation until the introduction of the third generation car navigation system 15 years later. The remainder of this section is organized as follows: First, the case study research design is explained. Then, the background of the project is presented together with an overview of the three different generations of the car navigation system. Subsequently the acquisition, dissemination and use of market information are discussed. Finally, the antecedents of market information processing that played a role in the car navigation project (R&D dominance and time pressure) are presented.

3.2.1 Case study research design

For this case study, a qualitative research approach was used to understand how market information is processed and to identify which factors influence market information processing during high-tech NPD. Based on the exploratory interviews one organization was selected to study market information processing and its antecedents in more detail. The company 'Car Communications Inc.' was chosen from the list of companies in table 1 as it allowed following market information processing across multiple generations of NPD.

Before starting the data collection process, full co-operation of senior management was secured. In total eight interviews were carried out, including a kick-off meeting with two project members and a presentation of the preliminary results to the project leader. In-depth interviews were conducted with employees from Sales (n=2), R&D (n=3), Strategic Marketing (n=1), Product Management (n=1), and General Management (n=1). An interview checklist was used to ask respondents about (1) their role in the organization, (2) the NPD process, (3) important decisions in the NPD process, (4) acquiring information, (5) disseminating information, and (6) using market information during the NPD process. The interviews lasted between 45 minutes and one and a half hours. Interviews were tape-recorded, transcribed and summarized. Transcripts of the interviews were analyzed according to the topics in the interview checklist. To check for inconsistencies, reports of the interviews were reviewed by all respondents. Based on the interview data, a summary was written that was presented to the project-leader who later became the general manager of the firm. In this final presentation, findings from the case study were compared with the insights of this key actor, and any remaining ambiguities were clarified by discussion.

3.2.2 Background of the car navigation project

This case study deals with market information processing in the development process of the first car navigation system in the European market. A car navigation system is an on-board computer that can plan the quickest route to a destination and provides the driver with guidance and traffic information. In 1984 the idea of car navigation emerged in a research

laboratory by combining two ‘visions’. People within the car navigation company were looking for an application for the emerging technology of satellite navigation with the Global Positioning System (GPS). At the same time there was a ‘shared vision’ that car radios had to be extended with more functionality, because car radios would become commodity products in the future. Combining these two visions resulted in the idea of a car navigation system that would solve the drivers’ problems with finding the quickest route to his/her destination. Ten years later the first car navigation system was introduced in the BMW 7-series for the European market (see Figure 3.1).

Whereas the first generation car navigation system started with BMW as the only (business-to-business) customer, later generations were sold to several original equipment manufacturers (OEM-customers) and to consumers in the aftermarket. The aftermarket refers to the consumer market where car navigation systems are sold directly to consumers through retailers. The OEM-customers are car manufacturers like BMW, who integrate the navigation system in their cars while they are still in the factory. They use their own brand-name for the car navigation system. The decision to develop a second-generation car navigation system that was also suitable for the aftermarket was made because selling systems to BMW only restricted the company to the introduction of certain car models. In the aftermarket (with an estimated size of 275 million cars in Europe) the system can be built in any car and large sales numbers can be realized faster.



Figure 3.1: First-generation car navigation system

Although the first-generation product generated higher sales than expected, the product had to be improved to become more attractive for the consumer market. The first-generation car navigation system was large and consisted of two boxes, one navigation computer and one man-machine-interface computer. The developers realized that for the aftermarket the size had to be reduced. So the aim for the second-generation was to fit all the components in one box and especially for the aftermarket there was a strong need for a

1-DIN sized box[1], so it could be built in every type of car. An OEM client like BMW saves space in the dashboard for the navigation system, so this demand was less important for the OEM-version.



Figure 3.2: Second-generation car navigation system

The second-generation navigation system was launched in 1997 (see Figure 3.2). The developers created a system that was a little bit wider than 1-DIN, but everything was placed in one box. The process of defining the requirements for the third-generation car navigation system started before the market introduction of the second generation. The main goals were better performance, a 1-DIN sized housing and cost reduction. The third-generation car navigation system was launched in 1999 (see Figure 3.3). It had a 1-DIN size and was sold in almost every European Union country and to European car manufacturers such as BMW, General Motors, Volkswagen, Renault and PSA (Peugeot and Citroën).



Figure 3.3: Third-generation car navigation system for OEM-customers (left) and for the aftermarket (right)

3.2.3 Acquisition of market information

One of the major challenges during the development of high-tech products is to determine the demand for products that don't exist from customers who don't yet know about them.

[1] 1-DIN refers to the universal size of car radios, where DIN is an abbreviation for the German national standards organization (Deutsches Institut für Normung).

During the car navigation project several approaches were used to gather market information from a market that did not yet exist. First, working demonstration models were used to get early market feedback. Second, co-operating with an OEM-customer resolved some of the market uncertainties. Finally, different types of market research were used to gather customer information.

Working demonstration models

In the car navigation project the developers built a working demonstration model to get early market feedback and to prove that the research project had enough potential to bring forth an interesting new technology: *'The first necessary step was transferring the idea to a demonstration model that could show the technical feasibility of the idea. This was not done with a real prototype, but it was more like using existing devices to demonstrate the function. A mini-computer with a screen and keyboard was placed in the back of a minivan. Several sensors were attached to the minicomputer with external cards and operated through software. On the mini-computer one could calculate the position of the minivan'* (Interview with hardware development manager).

The researchers also wanted to show that car navigation meant new business for their company and therefore they invited journalists to watch the working demonstration model and gain public attention. Positive publications in the press made the public enthusiastic about the idea and gave the public insight into what car navigation was. These reactions from the public and the press could be considered early market feedback. From the beginning the car navigation idea received a lot of media attention. By using the press in a smart way, the car navigation company managed to get a lot of free publicity for the car navigation system.

The demonstrations of the car navigation system convinced top management and brought the project into the next stage, getting the status and resources of an official product development project. The next assignment for the navigation development team was to develop prototypes that could be mounted into passenger cars to prove the functional feasibility to potential customers. In 1988 the prototypes were built into BMW and Volkswagen passenger cars to demonstrate the navigation system to these car manufacturers. With these prototypes the car navigation company convinced their first client, and for a long time their only client, BMW, to work with them in close cooperation and to take over part of the risks.

Co-operating with an OEM-customer

Developing for BMW resolved some of the market uncertainties during the car navigation project. For example, the estimations for the production numbers for the first- and second-

generation car navigation system came from BMW. Sales forecasts for the car navigation system were based on sales volumes that BMW had realized with other innovative options for their cars with a comparable price. If, for example, the price of an air-conditioning system was 10 percent of the price of a car and the price of a navigation system is also 10 percent of the price of a car, roughly the same percentage of BMW buyers that had chosen the air-conditioning in their previous BMW, will now choose a navigation system as an option in their new BMW. In practice, these estimations turned out to be on the low side: *'The forecasts from BMW and the product orders that were made had to be adjusted upwards within a few months. Thus, the response from the market was above expectations. I don't know the exact numbers, but I think that the original forecasts were somewhere between 5 and 10 thousand navigation systems and that it finally resulted in 40 or 50 thousands products for the first year'* (Interview with hardware development manager).

The first-generation car navigation system was developed with a detailed list of specifications from BMW. With their requirements, BMW gave direction to the design of later versions of the car navigation system, also for the aftermarket. For example, the controlling philosophy of the user interface was mainly influenced by BMW and determined the design of later versions. For this reason, the car navigation company did not conduct very extensive market studies to establish customer profiles for the first generation car navigation system. The profile for the first-generation was the BMW 7-series buyer, and the description of this target group was given by BMW: *'The market information that was used in developing the first generation product came from BMW. The input for this product came purely from BMW. The product managers gathered some market information, but that was merely trying out something. There wasn't an aftermarket product yet'* (Interview with hardware development manager).

Market studies

But later on, while developing the second-generation and the third-generation car navigation system, several market research agencies carried out more extensive market research to define more detailed customer subgroups. To give an overview of consumer and market studies in the car navigation history, table 3.2 shows a list of titles, dates and contents of these studies. Qualitative studies, were conducted in the beginning of the first generation development trajectory. An example is the 'alpha testing' (testing the product on the specifications that were defined) that was done with employees with the system built in their own cars. 'Beta tests' (user tests with consumers) and observation studies were also conducted in the early stages of the project, either with respondents in the ergonomics department or done by OEM customers in their own laboratories: *'Several tests were done with consumers. One of the proposals was developed into a simulation program and tested*

with a limited group of potential customers [car drivers of expensive cars]. These consumers were placed behind the simulation and observed, while they were asked to perform assignments' (Interview with hardware development manager). The more quantitative studies date from after the introduction of the second-generation car navigation system in 1997.

Table 3.2: Overview of market studies in the car navigation project

1990: qualitative observation study by the car navigation company
"25 minutes driving session", 16 respondents
1993: qualitative market study by MBA students
"Market study of the professional market for car navigation"

1994 - market introduction first-generation car navigation system

1994: quantitative market study
"Marketing study for Opel"
1994: qualitative competitor research by the car navigation company
"Market study of Japanese navigation market"

1997 - market introduction second-generation car navigation system

1997: qualitative user study by the car navigation company
"Strengths and weaknesses of the current car navigation system and opportunities for improvements"
1998: quantitative market study by Future Featuring, market research institute "UK aftermarket user study"
1998: quantitative market study by NIPO, market research institute "De Nederlandse Automobilist", 1577 respondents

1999 - market introduction third-generation car navigation system

1999: quantitative market study by Ogilvy One, market research institute "Car Owners Market Survey Germany & France", +/-1500 respondents
1999: qualitative innovation study by TUV, research institute "Innovationsstudie Fahrerassistenzsysteme"

Testing with customers revealed things like screen colours at night that had to be improved or parts of the menu structure that were somewhat demanding. Another complaint about the user interface of the second-generation car navigation system came from the company's own employees that had the system built into their cars. The map display didn't follow the current position smoothly and this was experienced as annoying: *'We have also built the systems in cars of employees, and not only those from development, with the request to provide technical feedback, but also ergonomic feedback. Several change requests came out of that stage. In the beginning, about 15 employees had such a system in their car for test-driving, but at the moment almost every employee has one. Nowadays, all*

employees receive an update for their system for a new release, so they can detect mistakes and do suggestions before the product hits the market' (Interview with hardware development manager).

Apart from market information collected with official studies and through employees, a lot of useful market input was generated more informally via end customers, the customer helpdesk, dealers, or people who were providing direct dealer support, who had feedback from dealers and the dealers' direct customers: *'I talked for example with service people. I don't remember all of their recommendations, but one was very clear. They would like to have extended diagnostic facilities. Connect a diagnostic tool to the system to be able to help a client with problems, to read out locked errors in the software or system status, typical service requirements. And similar requirements together with functional requirements came from OEM-service personnel'* (Interview with product manager).

3.2.4 Dissemination of market information

In the early stages of the project, developers collected the information they needed themselves, and thus there was no need to disseminate it, but as the organization became larger, the marketing department (Product Strategy and Planning) took over the responsibility for generating market information. The following quote illustrates the informal approach for the acquisition of market information in the early years: *'We knew the developers working on the project at BMW very well and if there was a problem, or new feedback from the market, then we just made a phone-call. We had very close contact, in the early years we had product managers working on the development and developers working on marketing'* (Interview with hardware development manager).

When the company increased in size, and the organization became more centralized and departmentalized, market information processing also became more difficult. One interviewee explained that the distance to customers had increased since the company became larger: '*In the past we got direct response from the customer, because we regularly visited them. Nowadays, every customer has its own line of business with an entire organization behind that. The result is that only a little information about customers goes directly to development*' (Interview with software manager). Thus, the increased size of the organization also increased the distance between marketing and development. Developers indirectly heard the requirements from the program manager who discussed everything with different car manufacturers. In this way, the dissemination of market information was sometimes hampered.

To enhance the dissemination of market information, the marketing department regularly (every few months) sent a digital newsletter with market research information (benchmark reports with competitors and market developments) to the developers.

Furthermore, information from the aftermarket was channelled through the organization by the use of a customer database. In this way, information that entered the organization through customer service was made visible to other members of the organization. A different way to disseminate market information was through technology roadmaps. For the third generation car navigation system, Product Strategy and Planning (PSP) made up priority lists in which they put together all the OEM and aftermarket input. This input consisted of complaints and suggestions for future product improvements that came back from the market. This market input came from OEM sales personnel, the company's own sales personnel, suppliers, the helpdesks and dealers and service engineers, both for the OEM and aftermarket. Together with what was possible at that time and what would be possible in the future, the PSP personnel fed these priority lists into technology roadmaps to do the feature planning. In these roadmaps it was defined which technologies had to be applied in future products.

Thus, at the start of the car navigation project, the dissemination of market information was less important, because developers acquired market information themselves by talking directly to customers. However, when the organization was growing in size, the dissemination of market information became more difficult because the organization became more centralized and departmentalized. The use of more formalized processes (such as marketing newsletters, customer databases and roadmaps) enhanced the dissemination of market information in later stages of the car navigation project.

3.2.5 Use of market information

Two types of market information were used during the car navigation project: Market information about the business environment and market information about consumers. However, the use of each type of market information depended on the stage of the product development process. Market information about the involved industry market participants was used to make decisions relating to technological challenges and technical improvements, to find resources and, for example, to establish the availability of digitised roadmaps. This type of market information was used more extensively in the first- and second-generation car navigation systems than market information about consumers. This broader type of market information was clearly more important for the course of the project in these first stages, because it was needed for crucial decisions on business development.

Market information about consumers was used more extensively from the introduction of the second-generation car navigation system onwards. The car navigation company began to develop a product platform and used consumer information for most changes in product specifications. For example, the integration of traffic information in the second generation car navigation system was a clear request from customers: *'From the second*

generation product onwards, when we had developed a halfway nice platform, the most changes were due to market input. There were lists with the most mentioned needs or remarks of customers. At the start of second generation product we had, for example, not yet traffic information in the system. And that is not a thing that comes out of itself, it's a market need, a customer need' (Interview with product manager).

Also feedback from testing with employees who had the system built in their own cars resulted in changes in the final product. For example, the map display in the third generation car navigation system was altered based on suggestions from employees: '*A shortcoming of the map display in the second generation product was that the map did not nicely and smoothly follow the current position, so we had the definition of a smooth following map display for the third generation. This complaint came from co-workers who had the system installed in their own cars. We solved it with hardware'* (Interview with product manager).

Some decisions in the car navigation project were based on both information about the business environment and information about consumers. For example, the decision to integrate GPS in the car navigation system was driven by technological developments and market information. The first prototypes used an electromagnetic compass, because GPS was too expensive. In 1991 the decision was taken to integrate GPS, because the price of this technology was decreasing rapidly and early customers found it awkward to use the electromagnetic compass: *'Getting rid of the compass was a decision that was influenced by feedback from the market. Comments from the market that the compass did not work played a major role in that decision. The necessity of integrating GPS was a clear request from the market that came from the BMW-customers'* (Interview with manager hardware development). The advantage of GPS was that it ruled out the need for entering a starting position or re-entering manually the cars exact position when the computer had become inaccurate because of the compass and sensors. Furthermore the installation costs for the electromagnetic compass were much higher and installation time was longer. Installing and calibrating the electromagnetic compass and wheel sensors and installing the computer, the wiring and the display could take two or three days. Losing the electromagnetic compass and wheel sensors and further integration of the components in the second generation system made installing it easier, but it was not before the third-generation of the system that the installation time was reduced to just a couple of hours.

Although market information was used throughout the entire car navigation project, many decisions were taken without using market information. For example, market information was not taken into account for setting the price of the navigation system. Because there were no competitors on the market yet while developing the first- and the second-generation car navigation system, there wasn't any market input used for defining the price for the aftermarket. The car navigation company used the development costs, the

production costs and desired margin to set a target. Also for integrating different functionalities there was no reference. The market was not 'asking' for any functionality. In addition, market information was not used for decisions about the appearance of the hardware. Designers made several suggestions for the looks of the car navigation system and then management decided upon this. These decisions were never tested in the market; they just had to fit in the car-radio line. Furthermore, information about competitors was not used in the early stages because there were no competitors present yet. The company was the first mover with a navigation system in the European market. At the time of the second generation, other companies had their first versions of a navigation system. According to the interviewees, information about competitors at such an early stage did not give real input for further work.

3.2.6 Antecedents of market information processing

In addition to the antecedents identified from the literature and similar to the results of the exploratory interviews (section 3.1), two potential antecedents of market information processing were found in the car navigation project: R&D dominance and time pressure.

R&D dominance

At the beginning of the car navigation project, the car navigation company had enough resources to let researchers play around. There was not the enormous pressure that a new idea had to become a product in the very near future. This might have caused a more internally oriented (R&D dominated) organization. In the interviews it was found that the company had a strong focus on technology and that marketing and sales had hardly any influence on NPD decisions. One brand manager explained in his own words that the company would score high on R&D dominance: *'Our company is very much technology-driven. We make something beautiful and when it is finished, we start to think about the market. Once or twice a year, the sales department gets to know the new products and they have no influence on product development, on the specifications of the product. Once in a while, and when the sales department is trying hard, some things are changed in a product in a so called 'running change', one year after introduction. Disseminating information to the top [development department] happens more on an occasional basis. Some sales offices have some influence on the strategic choices with regard to the products, but that's more focused on marketing issues. Marketing is adjusted to the product portfolio and not the other way around'* (Interview with brand manager).

In the same interview, this brand manager explained that the sales department made several suggestions for product changes based on market input, but that the organization did not react to that: *'Although competitors are using DVD in their systems, the head office*

doesn't want that. All sales offices have told the head office that they had to use DVD in their systems, but they just don't listen. In the same way, sales asked for telemetric solutions (such as GPRS/WAP)[2] *but nothing happens with this information. In the mean time, competitors are integrating these types of applications in their systems and we are getting even further behind than we already are'* (Interview with brand manager). Together, these observations indicate that R&D dominance could be negatively related to market information processing in high-tech NPD.

Time pressure

Time pressure was also present in several stages during the development process of the car navigation system. The recession of the early nineties was economically a bad time and had its effects on every industry group. The car navigation company had to cut costs and in 1993 the size of the development team was almost halved to 21 people. This resulted in a lot of time pressure, as BMW wanted to be the first car brand on the market with a navigation system as an option: '*At some point time, we had to work late almost every weekend because they said: "If we haven't got something finished after this weekend that BMW accepts, the project is killed'* (Interview software manager).

In contrast to the exploratory interviews, time pressure was found to have a positive influence on market information processing in the case of the navigation project. To cope with high amounts of time pressure, NPD team members had to work in task-forces with BMW as a way to optimize efficiency: *'A lot of work had to be done in the last months to complete the navigation system on time. The close co-operation with BMW and the use of, so called, TIGER-teams helped to accomplish this'.* In this way, developers had direct access to customer information from BMW. Thus, time pressure resulted in an organizational structure which improved efficiency and market information processing during the car navigation project.

3.2.7 Summary of case study findings

The objective of this case study was to focus on one product development project to understand how market information is processed and to find out which factors influence market information processing during high-tech NPD. It was found that the idea for car navigation was based on a vision of how markets and technologies would develop in the future. Market uncertainty in the early stages of development was partly resolved by building early prototypes and showing them to top management, potential customers and the press.

[2] GPRS refers to 'General Packet Radio Service', a mobile data service where the user pays for the amount of data he/she requests. WAP is an abbreviation for 'Wireless Application Protocol', a technique to offer web services to a mobile phone.

Particularly the demonstration of prototypes to journalists proved to be an effective way to convince management of the project's importance and to get early feedback from the market. The acquisition of market information in the early stages occurred primarily through direct contact with one business-to-business customer. In later stages, and after the company had entered the consumer market, market research was conducted more systematically. This also had consequences for the dissemination of market information. When developers interacted directly with customers there was no need to disseminate information. However, when the organization became larger and market research was centralized, there was a greater need to disseminate market information throughout the organization. Information about the business environment and consumer information were used in different stages of the NPD process. This resulted in several changes to the design of the product (e.g., integration of traffic information and lay-out of the map display). Similar to the findings of the exploratory interviews, the case study also revealed that R&D dominance and time pressure are antecedents of market information processing. Together with the results from the exploratory interviews, the findings from the case study are combined with the findings from the literature review to build a conceptual framework in chapter 4.

Chapter 4 - Building the conceptual framework

This chapter synthesizes the results from the literature review (chapter 2) and the interviews with practitioners (chapter 3). Previous chapters showed that market information processing and NPD can be considered organizational competences that help to create a competitive advantage. Most empirical studies on market orientation and NPD have found positive associations between market information processing and new product performance. In addition, several antecedents of market information processing have been found. The interviews with practitioners identified new antecedents for new high-tech products such as project priority and R&D dominance, while the literature review revealed other factors like formalization, centralization and interdepartmental conflict. Chapter four is divided into two parts. First, the chapter discusses the consequences of market information processing in different stages of the NPD process, and develops hypotheses for the effects of market information processing variables on new product outcomes. Second, the chapter develops hypotheses for three sets of antecedents (project urgency characteristics, company structural characteristics and company cultural characteristics) of market information processing in NPD. By synthesizing the literature and interviews with practitioners this chapter presents a conceptual framework that connects antecedents to the outcomes of market information processing in high-tech NPD.

4.1 Consequences of market information processing

Market orientation has received much attention in the literature and in managerial practice for its apparent positive effect on organizational performance (Jaworski and Kohli 1993, Narver and Slater 1990). Market orientation leads to superior organizational performance, at least in part, because of the new products that are developed and brought to market (Gatignon and Xuereb 1997). A behavioral market orientation is inherently a learning orientation (Slater and Narver 1995), which means that a firm's market orientation develops from the market information processing activities that the organization uses to learn (Kohli et al. 1993). According to the organizational learning literature, information-processing activities include acquiring, disseminating and using information (Sinkula et al. 1997). Previous research has shown that a critical element of market information processing is the actual use of market information, which has been shown to have a positive effect on successfully developing new products (Atuahene-Gima 1995, Moorman 1995, Ottum and Moore 1997). The current section relates market information processing variables to new product outcomes. Based on the extant literature, this section develops a conceptual framework to investigate market information processing variables – information acquisition, dissemination and use – in three generic NPD stages: predevelopment, development and commercialization, and to find out

whether information use in the different stages has any relationship with achieving product advantage and new product performance. Figure 4.1 presents the conceptual framework for the consequences of market information processing. The remainder of this section discusses the conceptual framework in the order of the hypotheses, starting with the proposed relationship between product advantage and new product performance, the ultimate goal of the firm and therefore the ultimate dependent variable.

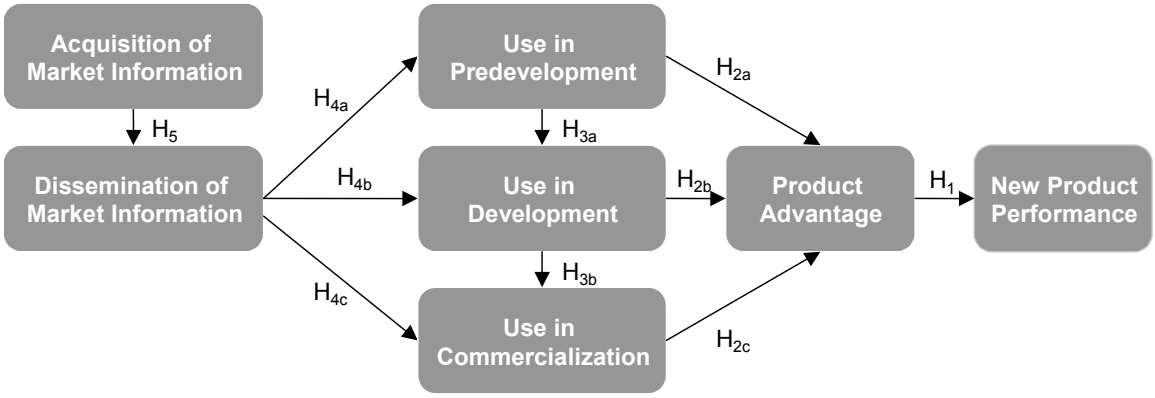


Figure 4.1: Conceptual framework of market information processing and NPD outcomes

4.1.1 Product advantage and new product performance

According to Rogers (2003), the adoption of a new product by the market is positively influenced by the new product's advantages over competing products. When a product allows a customer to do something they have not been able to do previously by offering new benefits, higher quality or superior solutions to problems, then that product has an advantage over other products already on the market (Calantone and di Benedetto 1988). New product advantage consistently has been found as one of the major success factors in NPD (Cooper 1985, Henard and Szymanski 2001, Montoya-Weiss and Calantone 1994). In a meta-analysis on the determinants of new product success, Montoya-Weiss and Calantone (1994) identified product advantage as the factor with the strongest association with new product performance. In a more recent meta-analysis, Henard and Szymanski (2001) also found product advantage a dominant driver of new product success. Following the well-supported previous empirical evidence, it is hypothesized that:

H1: New product advantage is positively related to new product performance.

4.1.2 Market information use and product advantage

Initial empirical research suggests that achieving product advantage is associated with market information use, which has been defined as taking information about current and future needs of customers and external factors such as competition and technology changes into account when making decisions (cf. Veldhuizen et al. 2006). For example, Sethi (2000)

found that integrating market information into the project was positively related to new product quality. However, in this research these variables were measured only for the project in its entirety.

In previous chapters, the NPD process has been divided into three generic stages: predevelopment, development and commercialization, rather than being treated in total. Across the different stages of the NPD process, market information can be used to make better decisions; for example, what problems the customer wants solved, what features to build into the final product, whether the product truly meets customer needs, whether the product operates in reality as was planned, and how to communicate the benefits to consumers effectively (Calantone and di Benedetto 1988). Each stage requires different market information to achieve product advantage (Zahay et al. 2004). Because information is used differentially across stages, potential relationships with product advantage should be considered differentially. This leads to the following hypothesis:

H2: Market information use in the (a) predevelopment, (b) development, and (c) commercialization stages is positively related to new product advantage.

4.1.3 Market information use across NPD stages

Market information about customer needs and wants is used in both the predevelopment and later in the development stage of the NPD process (Zahay et al. 2004). In addition, information about the set of potential customers is used in the predevelopment and later in the commercialization stages (Zahay et al. 2004). A team's culture and process are set at the beginning of an NPD project. If a team initially is unwilling (or unable) to look outside its boundaries for information inputs, that attitude (or capability) is unlikely to change in later stages of the development process. Moreover the theory of absorptive capacity suggests that the accumulation of prior knowledge enhances the ability to acquire new knowledge (Cohen and Levinthal 1990). Thus, teams that gain new knowledge from using market information early in the process are likely to understand its value and use it in the later stages of the process as well (Marsh and Stock 2003). In other words, if decisions are based on market information in the early stages of NPD, as Zahay et al. (2004) suggest they need to be, it is likely that market information also will be taken into account in later stages. This leads to the following hypothesis:

H3: Market information use in predevelopment is positively related to (a) use in the development stage; and market information use in development is positively related to (b) use in the commercialization stage.

4.1.4 Market information acquisition, dissemination and use

Research on the learning organization has shown that before information can be used, it first must be acquired and then disseminated to the right people (Baker and Sinkula 2002,

Sinkula 1994, Sinkula et al. 1997). According to Day (1994), effective learning about markets is a continuous process that pervades all decisions. Continuous market learning helps managers repeatedly anticipate market opportunities and respond before their competitors, providing the opportunity to create competitive advantage for the firm. Daft and Weick (1984) modeled learning processes in organizations, such as those involved here with market information learning processes, as a three-stage process. The first stage is “scanning,” or data collection. The next stage required before learning can occur is “interpretation,” or giving meaning to the data collected. The final stage is “learning,” taking action on the information and actually using it. This model specifically orders these three stages temporally, suggesting that information cannot be used unless it is first collected, and then given meaning.

In a similar way, NPD activities can be considered as information processing activities aimed at reducing uncertainty (Moenaert and Souder 1990). Since the nature of the innovation process is essentially informational, innovation teams can be viewed as information processing subsystems: a team obtains market information from others both inside and outside the firm, disseminates it to those who need it, and uses this information to create a product design (Souder and Moenaert 1992). Temporally, information must be acquired before it can be disseminated, and disseminated to the appropriate people (those who need it), before it can be used (Sinkula et al. 1997, Zahay and Griffin 2004). This temporal logic leads to the following hypotheses:

H4: Market information dissemination is positively related to market information use in the (a) predevelopment, (b) development, and (c) commercialization stages.

H5: Market information acquisition is positively related to the dissemination of market information.

In addition to understanding the outcomes of market information processing, this research aims to identify antecedents of market information processing for new high-tech products. Although market information processing is an important ingredient for successful NPD (e.g., Atuahene-Gima 1995, Ottum and Moore 1997), organizations often consider this problematic. Many firms do not actively incorporate market information into their new products (Ottum and Moore 1997) or fail to use the market information that is available to them (Maltz and Kohli 1996). An important question therefore is why companies decide to process, or not to process, market information in their development projects. To provide initial answers to this question, this research identifies several antecedents of market information processing in the development process of new high-tech products. The next section discusses the antecedents of market information processing in NPD and develops individual hypotheses for each of the antecedents.

4.2 Antecedents of market information processing

An examination of the literature and the insights from the practitioner interviews identified three sets of antecedents to market information processing during the development process of high-tech products: Project urgency characteristics, company structural characteristics and company cultural characteristics (See figure 4.2). Project urgency characteristics were derived primarily from the interviews but also have theoretical and empirical backing in the literature on high-tech NPD, consumer research and in the innovation literature in general (e.g., Payne, Bettman and Johnson 1993, Sethi 2000, Workman 1993). Project urgency characteristics refer to the priority given to an NPD project and the amount of time pressure that was felt during a project. Together, these characteristics indicate the importance and the sense of urgency that is experienced during an NPD project.

Company structural characteristics are factors at the firm-level that were derived from the innovation, market orientation, R&D/marketing interface and information use literatures (e.g., Burns and Stalker 1961, Deshpandé and Zaltman 1982, Gupta and Wilemon 1988, Kohli and Jaworski 1990). Company structural characteristics refer to the ways in which an organization is structured to divide labor into distinct tasks and achieve coordination among them (Mintzberg 1979).

The third set of antecedents, company cultural characteristics, is a mix of factors at the firm-level derived from the interviews with practitioners and the literature on strategic marketing and management, marketing's influence in NPD, and the literature on radical innovations (e.g., Atuahene-Gima and Ko 2001, Chandy and Tellis 1998, Li and Atuahene-Gima 2001, Slater and Narver 1995). Culture is the pattern of shared values and beliefs that provides norms for behavior in the organization (Deshpandé and Webster 1989).

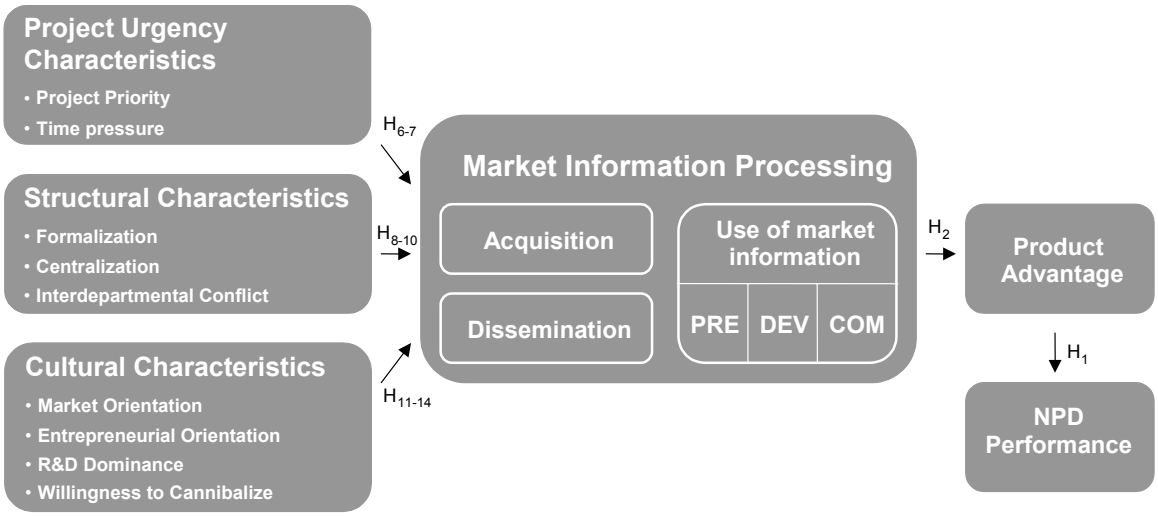


Figure 4.2: Conceptual framework of antecedents of market information processing in NPD

All antecedents are hypothesized to impact market information processing during the development process of new high-tech products. Although market information processing was previously considered as a temporal structure (consisting of the acquisition, dissemination and use of market information in the predevelopment, development and commercialization stages of NPD), here the individual components are treated as one integrated construct for reasons of efficiency. In the next section the three sets of antecedents are discussed and hypotheses for each of the antecedents of market information processing are developed.

4.2.1 Project urgency characteristics

The first set of antecedents is mainly derived from the interviews with developers of new high-tech products. Combined with a review of the literature, two factors related to project urgency are considered the most relevant for market information processing in high-tech NPD. The interviews indicated that the priority given to an NPD project and the time pressure felt during the project were important factors influencing market information processing (See figure 4.2). The individual project urgency characteristics are now discussed in more detail.

Project priority

The interviews uncovered that the priority given to a project can influence whether NPD decisions are based on market information. Project priority refers to the importance and the status of a NPD project, compared to other projects also in development. NPD projects often have to compete for resources with other projects, since companies often have too many projects for the limited resources available (Cooper, Edgett and Kleinschmidt 2000). When a project is highly important to a company, one may expect that more resources will be spent on it and more attention will be paid to market information processing in the NPD process. In a study on project acceleration, Swink (2003) theorized that development personnel who sense a high level of project priority are likely to become more interested in the project, and give greater attention to project activities. In prior empirical studies, project priority has received much discussion, but little empirical support. However, Ottum and Moore (1997) found that project priority was positively related to the acquisition and use of market information. The previous discussion leads to the following hypothesis:

H6: Project priority is positively related to market information processing in high-tech NPD.

Time pressure

Time pressure is defined as the extent to which team members believe that they have a shortage of time during a specific NPD project (Sethi 2000). According to Workman (1993)

there is a lot of pressure on design teams to make decisions fast, especially in technologically turbulent markets. The findings from the exploratory and case-study interviews showed that time pressure is an important factor in high-tech NPD projects and that it may decrease market information processing.

Consumer research also has demonstrated that time pressure affects information processing by consumers. One study about the way consumers make choices found that time pressure reduces the quality of decision-making (Payne et al. 1993). In another study, Wright (1974) found that subjects under high time pressure take fewer dimensions into account when evaluating cars. The perception of a shortage of time may lead people to process more general information about alternatives instead of gathering detailed information about particular alternatives.

Based on the fact that time pressure is negatively related to information processing by consumers, the findings from the interviews, and the logic that under high levels of time pressure, less time can be spent on market information processing, it is hypothesized that:

H7: Time pressure is negatively related to market information processing in high-tech NPD.

4.2.2 Company structural characteristics

The second set of antecedents proposed to influence market information processing refers to company structural characteristics. At the company level, Mintzberg (1979) defined organizational structure as the sum total of the ways in which the organization divides its labor into distinct tasks and then achieves coordination among them. Thus, an organizational structure defines how tasks are formally divided, grouped and coordinated.

There have been numerous studies exploring the link between organizational structure and innovative performance. Most of the research in this area dates back to the influential work of Burns and Stalker (1961). In their view, organizational structures can be classified along a continuum from mechanistic to organic. Mechanistic organizations are characterized by high levels of formalization, centralization and departmental boundaries, and tend to make decisions slowly. Organic organizations, on the other hand, have informal and decentralized structures, communicate more openly, and make decisions quickly. Based on their classification and the investigation of Scottish electronics companies, they argued that in dynamic environments, firms with an organic structure are more effective than those with a more mechanistic structure (Burns and Stalker 1961). This implies that informal and decentralized structures with little interdepartmental conflict would be more valuable in competitive and innovative technological markets.

Dougherty (1990) was the first to establish a link between organizational structure and market information processing. In embedded case-studies in the computer/

communications and chemical industries she found that organic structures were positively related to the amount of market information processing and new product success (Dougherty 1990).

Similar to previous studies on market orientation (Kohli and Jaworski 1990) and based on the innovation literature (Burns and Stalker 1961, Dougherty 1990) this research considers three structural antecedents for their potential effect on market information processing: *Formalization*, which is the degree to which standardized rules and procedures describe how activities are performed; *centralization*, or the concentration of decision-making authority at a higher level of the company's hierarchy (Jaworski and Kohli 1993, Moorman et al. 1993); and *interdepartmental conflict*, which refers to the tension between two or more departments that arises when they have divergent goals and a functional rather than organizational perspective.

Formalization

Formalization has been defined as the degree to which rules define roles, authority relations, communications, norms and sanctions, and procedures (Hall, Haas and Johnson 1967). A formalized organization has clear performance standards, clear delineation of responsibilities via policies and job descriptions, and well defined guidelines for handling work situations (Gupta and Wilemon 1988). The potential effects of formalization have been investigated in different research areas.

In the market orientation literature, formalization has been considered for its negative effect on behavioral market orientation because it is supposed to make organizations less adaptive to market changes. If rules define roles in an organization, managers may be less aware of important events outside their formal roles (Deshpandé and Zaltman 1982). Thus, formalization may inhibit a firms' information utilization and thus the development of effective responses to changes in the marketplace (Kohli and Jaworski 1990). However, in a recent meta-analysis on the most frequently examined antecedents of market orientation, Kirca et al. (2005) did not find a significant effect of formalization on market orientation in the multivariate analyses.

In the innovation literature, formalization also has been identified as an impediment to spontaneity and flexibility (Sivadas and Dwyer 2000). Other researchers suggest however, that formalization may lead to more formal and disciplined NPD-processes with a better integration of market information (Cooper and Kleinschmidt 1986). This literature is thus equivocal on the expected directionality of this relationship.

Research on formalization also has been conducted in the field of communication and the R&D/marketing interface. Both Ruekert and Walker (1987) and Gupta and Wilemon (1988) found that formalization leads to better R&D/marketing cooperation. More recently,

Rein (2004) described that formalization of the NPD process helped a Fortune-500 company to foster synergy between marketing and R&D, increasing interaction between the groups. Together, these findings indicate that a formalized structure may stimulate the dissemination of market information through better communication.

Finally, formalization has been considered as one of the most important variables affecting marketing information use in the marketing organization literature (Deshpandé and Zaltman 1982). John and Martin (1984) investigated the effects of organizational structure during planning activities and found that formalization was positively related to the credibility and utilization of the marketing plan output. Based on their study of trust in market research relations, Moorman et al. (1993) suggested that formalization positively influences the use of market information through the degree of trust that managers have in the providers of market information.

To summarize, most empirical studies on formalization have found a positive relationship between formalization and several components of market information processing. Although the market orientation literature has not found clear support, there is some evidence of a positive link between formalization and market information dissemination through increased interfunctional communication. Furthermore, most evidence in the marketing organization literature suggests that formalization is positively related to market information use. Thus, following the majority of the empirical findings on the relationship between formalization and market information processing leads to the following hypothesis:

H8: Formalization is positively related to market information processing in high-tech NPD

Centralization

The term centralization refers to the concentration of decision-making authority at higher levels of the company's hierarchy[3] (Aiken and Hage 1968, Jaworski and Kohli 1993, Moorman et al. 1993). In highly centralized organizations, decision-making and power is concentrated in the hands of top management and few important actions are taken without the approval of managers. Therefore, centralization creates an environment with little decision-making participation by line employees and reduces communication among organizational members, which can be an important barrier to new product success (Sivadas and Dwyer 2000). In a decentralized organization, on the other hand, more people provide input into decisions, lower-level employees are free to do what they think is good for the organization, and there are fewer organizational levels involved in decision-making. Most organizations are neither completely centralized nor decentralized. One of the advantages of

[3] In the NPD literature, centralization also has been referred to as the presence of highly central team members who dominate discussions and searches for innovative solutions (cf. Leenders et al. 2007). This conceptualization is different from the one used here, which refers to a company's hierarchy.

decentralization is that information and decisions are processed more quickly because there are fewer levels of employees involved. Generally, if the environment of an organization is dynamic, a decentralized approach may be preferred (Gatewood, Taylor and Ferrell 1995).

Previous research on the R&D/marketing interface has shown that centralization has a negative impact on communication and the level of co-operation between marketing and R&D functions (Gupta and Wilemon 1988, Moenaert and Souder 1990, Moenaert et al. 1994). However, Moenaert et al. (1994) suggest that centralization may have different effects on the individual components of information processing. Centralization may be detrimental for the dissemination of information, but it may at the same time be beneficial for efficient decision-making. In addition, Song and Parry (1993) propose that the ideal level of centralization may vary across various stages of the NPD process.

In the marketing organization literature, John and Martin (1984) found that centralization was negatively related to the use of marketing plans. Furthermore, Deshpandé and Zaltman (1982) reported that market research for consumer products was applied more often to solve problems or make decisions when the organization was decentralized. The authors therefore conclude that decentralized firms are more likely to make greater (and perhaps better) use of market research than differently structured companies (Deshpandé and Zaltman 1982). In a later study, Deshpandé and Zaltman (1987) focused on industrial firms and found no significant relationship between centralization and the use of market information.

To summarize, there may be differences in the relationship between centralization and individual components of market information processing. Furthermore, the relationship between centralization and market information processing may depend on the specific setting of a study, but in general, negative relationships between centralization and market information processing have been found. Taking the majority of the empirical findings into account and combining this with the logic that the concentration of decision authority at higher levels in the organization is less effective for market information processing, leads to the following hypothesis:

H9: Centralization is negatively related to market information processing in high-tech NPD.

Interdepartmental conflict

Interdepartmental conflict is the tension between two or more departments that arises from having divergent goals and a functional rather than an organizational perspective (based on Gatewood et al. 1995, Jaworksi and Kohli 1993). Large organizations often are structured into functional departments where different groups perform activities that must be coordinated. For example, commercial development activities reside in the marketing

department and technological development activities in the R&D department. Although departmentalization is supposed to offer economies of scale, one major disadvantage of a departmental structure is that it often results in conflict when departments have different interests (Gatewood et al. 1995). For example, in NPD, R&D would like to optimize technology and wants precise answers as to what new product characteristics potential customers prefer. Marketing, on the other hand, would like R&D to freeze their new product feature set as soon as possible to facilitate market research (Gupta and Wilemon 1988).

Research has predominantly shown a negative relationship between interdepartmental conflict and market information processing (Jaworski and Kohli 1993, Ruekert and Walker 1987). According to Gupta and Wilemon (1988), R&D personnel may be afraid of being misled by marketing and are less likely to use market information when there is a high degree of conflict between marketing and R&D. Jaworski and Kohli (1993) studied the effects of interdepartmental conflict on the individual components of market orientation and found that interdepartmental conflict lowers information dissemination and responsiveness to market needs, while it is not related to the acquisition of information. Maltz et al. (2001) linked organizational variables to the information processing behaviors of R&D managers and found that interfunctional rivalry reduces the use of information. Kirca et al. (2005) examined interdepartmental conflict in their meta-study on market orientation and found a negative and significant bivariate relationship.

Based on these previous findings, it can be expected that higher levels of interdepartmental conflict are associated with lower levels of market information processing. This leads to the following hypothesis:

H10: Interdepartmental conflict is negatively related to market information processing in high-tech NPD.

4.2.3 Company cultural characteristics

The third set of antecedents proposed to influence market information processing in high-tech NPD refers to company cultural characteristics. Culture is the pattern of shared values and beliefs that provides norms for behavior in the organization (Deshpandé and Webster 1989). Cultural characteristics may be important antecedents of behaviors in the context of market information processing and NPD. For example, Slater and Narver (1995) mention two key elements of culture that are antecedents of the learning organization: cultural market orientation and entrepreneurial orientation. According to Atuahene-Gima and Ko (2001) market and entrepreneurial orientations have an effect on how organizational members process information and react to the environment, and lead to congruent behaviors at the NPD team level. The interviews with practitioners identified R&D dominance as an additional potential cultural characteristic that may be an impediment to effective market information

processing in NPD. Based on the marketing literature a fourth element of culture was identified: a company's willingness to cannibalize. If firms are more willing to cannibalize past investments they need to process market information before making new investments. Although willingness to cannibalize has been identified as an important variable for radical innovation (Chandy and Tellis 1998), it has not yet been studied in the context of market information processing. To fill this gap in extant knowledge, this research considers a company's willingness to cannibalize as an antecedent of market information processing for high-tech products. The section continues with the development of separate hypotheses for each of the four cultural antecedents.

Cultural market orientation

The first cultural antecedent to market information processing in NPD is a cultural market orientation at the organizational level. Narver and Slater (1990) define cultural market orientation as "the organizational culture that most effectively and efficiently creates the necessary behaviors for the creation of superior value for buyers and, thus, continuous superior performance for the business". Homburg and Pflesser (2000) empirically investigated the relationships between culture and behavior and find that both market oriented values and norms have indirect effects on market oriented behaviors (generating, disseminating and responding to market intelligence, which in this thesis is referred to as market information processing). This leads to the following hypothesis:

H11: Market orientation is positively related to market information processing in high-tech NPD.

Entrepreneurial orientation

An entrepreneurial orientation allows companies to have a better knowledge of their current and future customers, competitors and their business environment (Atuahene-Gima and Ko 2001). Matsuno et al. (2002) summarized the strategic management and entrepreneurial literatures and found three underlying dimensions of an entrepreneurial orientation: innovativeness, risk taking and proactiveness. The authors reasoned that these three dimensions collectively facilitate organization members' willingness and ability to engage in market intelligence activities and responsiveness, thus promoting a behavioral market orientation as defined by Kohli and Jaworski (1990). In other words, an entrepreneurial orientation may stimulate market information processing activities because of the innovativeness, proactiveness and willingness to take risk. Matsuno et al. (2002) tested their conceptual framework and found that an entrepreneurial orientation has a direct impact on acquiring, disseminating, and using market information and an indirect impact on a market orientation through departmentalization. Surprisingly, an entrepreneurial orientation was

negatively related to business performance (ROI), but the positive indirect effect on performance through market orientation was larger. These findings made the authors conclude that the effect of an entrepreneurial orientation on performance is not a direct one but is an indirect one through market intelligence activities and responsiveness.

Several studies have investigated the effects of an entrepreneurial orientation on organizational learning, again defined as the acquisition, dissemination and use of information. Narver and Slater (1995) argue that companies should complement market orientation with an entrepreneurial drive or a 'spirit of entrepreneurship', to maximize their ability to learn about markets. Liu, Luo and Yi-Zheng (2002) investigated the effect of an entrepreneurial orientation on market learning and organizational outcomes in Chinese state-owned enterprises. Their results show that the relationship between an entrepreneurial orientation and organizational outcomes is fully mediated by organizational learning. By combining these findings it can be expected that an entrepreneurial orientation has a positive effect on market information processing activities. This leads to the following hypothesis:

H12: Entrepreneurial orientation is positively related to market information processing in high-tech NPD.

R&D dominance

Innovation can be viewed as a socio-political process where the power and roles of each of the involved functions may differ over various types of decisions (Li and Atuahene-Gima, 2001). For example, marketing and R&D play key roles in NPD where marketing may mainly influence decisions about customer benefits, and R&D may dominate decisions about technical specifications of a new product. According to Atuahene-Gima and Li (2000) much of the literature on NPD fails to consider the political nature of the NPD process. Notable exceptions are studies by Workman (1993, 1998) who adopts a coalitional perspective and views the firm as composed of subunits with different levels of influence. According to Workman (1993), in high-tech firms R&D often dominates the marketing function in NPD decisions.

High-tech firms often place a high value on people with technical skills and provide a high status to technical personnel (Workman 1998). So far, the influence of R&D dominance on market information processing has not been investigated empirically. One indication of the potential effect of R&D dominance on market information processing comes from Workman's (1993) participant observation study in a computer systems firm. In this high-tech firm most vice presidents and senior managers had technical backgrounds and justified the power and influence of engineering. Product managers were part of engineering and project managers were responsible for the technical and engineering aspects of development. Employees did not use market research because they were skeptical about the outcomes, something that

was supported by the attitude of senior management. These findings made Workman (1993) conclude that an engineering-driven culture may be one of the greatest impediments to inputs from marketing.

The findings from the interviews with practitioners in chapter 3 indicated that R&D dominance could be an impediment to effective market information processing. Product managers with a technical background, engineers in management teams, and a large number of technical employees indicate the dominance of the R&D function. Too much R&D dominance may lead to a strong belief in the technical superiority of the product, and to a lower allocation of resources to market research. Combining the above mentioned findings about the dominance of the R&D function in many high-tech firms leads to the following hypothesis:

H13: R&D dominance is negatively related to market information processing in high-tech NPD.

Willingness to cannibalize

Willingness to cannibalize refers to the extent to which firms are prepared to give up the old and embrace the new, and to which a firm is prepared to reduce the value of past investments. A company's 'willingness to cannibalize' has previously been found to be an important predictor of radical product innovation (Chandy and Tellis 1998).

Chandy and Tellis (1998) found that in certain situations cannibalization is a desirable trait and can promote radical product innovation and the long-term success of the firm. If firms are more willing to cannibalize past investments they may be more sensitive to market developments in order to find new market opportunities. In addition, firms that are willing to cannibalize, may actively search for market information and try to find new customers and new markets for their new technologies. Although willingness to cannibalize has not been investigated in the context of market information processing, it can be expected that companies that are more willing to cannibalize their past investments will gather, disseminate and use more market information while developing new technologies. This leads to the following hypothesis:

H14: A greater willingness to cannibalize is positively related to higher levels of market information processing in high-tech NPD.

4.2.4 Summary and conclusions

Chapter 4 developed the conceptual framework for the antecedents and consequences of market information processing in high-tech NPD. Section 4.1 presented the hypotheses for the consequences of market information processing. The use of market information in the three generic of NPD was expected to be positively related to product advantage, which in

turn was considered for its expected positive association with new product performance. Furthermore, market information use in a certain stage was expected to be positively related to using market information in a previous stage. The temporal structure of market information processing resulted in one hypothesis linking dissemination to the use of market information and another hypothesis linking acquisition to the dissemination of market information.

Section 4.2 presented the hypotheses for the antecedents of market information processing during high-tech NPD. In total, three sets hypotheses were formulated regarding the impact of project urgency characteristics, company structural characteristics and company cultural characteristics on market information processing variables. Although market information processing was treated as one integrated construct in the hypotheses, differential effects of antecedents on components of market information processing will be examined in the empirical analyses.

The next chapter describes how the hypotheses that were developed in chapter 4 were tested. First, the mail survey research approach is explained. Then, the procedure of selecting respondents and the sample characteristics are described. Subsequently, the development and validation of the measures for the variables in the conceptual framework are presented.

Chapter 5 – Research method

The current chapter describes the research method and the measures that were used for specifying the conceptual framework. A mail survey research approach was used to collect data from NPD managers in high-tech industries. After a careful screening process, 550 questionnaires were distributed to key-informants. The responses to 166 completed questionnaires were used to purify the measurement constructs with exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). This chapter presents the results of these steps and is structured as follows: First, section 5.1 explains why a mail survey approach was chosen. Then, section 5.2 describes the development of the survey research instrument and section 5.3 discusses the operationalization of each of the variables. Section 5.4 describes the mail survey administration and shows the sample characteristics. Section 5.5 determines the unidimensionality, reliability and validity of the measurement constructs. Finally, section 5.6 concludes the chapter.

5.1 Introduction

The main objective of this research project is to understand the relationships between antecedents and consequences of market information processing during high-tech new product development. The previous chapters described the development of a conceptual framework. The current chapter describes the mail survey research approach that was used to collect data on new product development projects for specifying the relationships in the conceptual framework. Denzin (1989, p.144) defines a survey as a "methodological technique that requires the systematic collection of data from populations or samples through the use of the interview or the self– administered questionnaire". The latter approach, which is also called a mail survey, was used to collect data in this research.

The mail survey research method is an efficient approach to specify the conceptual framework empirically. Self-administered surveys are relatively inexpensive and are useful for describing the characteristics of a large number of firms (Dillman 1978). For these reasons, the mail survey research approach was chosen for gathering data in this study. Table 5.1 provides an overview of the steps that were taken during the mail survey research process. First, a survey research instrument was developed and pre-tested through face-to-face interviews with nine NPD managers. The goal of these interviews was to refine the measures that were used in the questionnaire and to clarify ambiguities. The second step involved a quantitative pilot survey to test the measurement scale properties. By the end of the second phase of pre-testing the questionnaire was ready to collect data and specify the conceptual framework. The next sections describe the different phases of the mail survey research process in more detail.

Table 5.1: Survey research phases and purpose of studies

Pilot interviews (n=9)	Exploratory structure, scale construction
Pilot mail survey (n=46)	Exploratory structure, scale reliability
Main mail survey (n=166)	Confirmatory structure, model specification

5.2 Questionnaire development

During the spring and early summer of 2002, a thirteen-page questionnaire was developed. The relevant literature and pilot interviews with NPD managers guided the development of the survey research instrument. The questionnaire was pre-tested and revised accordingly. The first pretest was conducted with nine NPD-managers: One marketing manager, two R&D managers, three product managers, two managing directors, and one software developer. This part of the study was carried out from February 2002 to May 2002. In all cases, the respondents completed the instrument in the presence of the researcher, giving comments on the questions as they were read and completed. Interviewees filled out the questionnaire and elaborated on questions that were unclear or could be interpreted incorrectly. Based on the feedback from these interviews the structure of the questionnaire was adjusted, four items were removed and 23 items were adapted. For example, the questionnaire contained several items referring to consumers, whereas more than half of the respondents were active in business-to-business markets. Therefore, the phrasing of the questions was made more suitable for both consumer and industrial markets. These and other suggestions were integrated in the next version of the research instrument.

For the second pretest, 150 questionnaires were distributed to test the initial properties of the measurement scales. From a commercial mailing list with high-tech companies, 110 firms were contacted by telephone and 57 managers (52%) agreed to participate. Reasons for not participating in the research were that the company developed services rather than physical products or the company had not recently introduced a new product in the market. In addition, 93 questionnaires were distributed at an NPD conference for high-tech firms and a management seminar on strategic marketing. After a reminder phone-call to the non-responding firms in the mailing list, 46 usable questionnaires (31%) were received. Appendix 3 presents summary statistics and Cronbach's alphas of the measurement scales from the second pretest. Based on the descriptive statistics several changes in wording were made in order to increase the use of upper and lower bounds of the scales. All measures in the second pretest had Cronbach's alphas higher than .70, suggesting that they would be reliable in the final sample.

5.3 Measure development

The questionnaire contained two open ended questions that asked respondents to describe the selected product and its benefits (Appendix 4 presents the answers to these questions). The main advantage of open ended questions is that they allow respondents to answer in their own frame of reference, uninfluenced by any specific alternatives suggested by the interviewer. On the other hand, open ended questions are more difficult to code and analyze than closed questions (Dillman 1978, Fink 1995). Therefore, all remaining constructs were measured with multiple-item scales. Most multi-item scales were drawn from prior studies, although some had to be newly developed or adapted from the organizational level to the project level. Respondents answered all questions using 5-point Likert-type scales (1 = strongly disagree, 5 = strongly agree).

To ensure that the content and meaning of the original items remained the same in Dutch as they were in the original English, a double translation procedure was used (Douglas and Craig 1983, McGorry 2000). First, two experts in both languages translated all English items into Dutch. A second group of experts translated the Dutch items back into English. Differences in translation were resolved by discussion. In some cases, the wordings of the translations had to be changed to arrive at correct Dutch sentences. Finally, the translations were compared to the original English items for any inconsistencies, mistranslation, or difference in meaning. This process resulted in Dutch items that were as identical to the English items in both content and meaning as possible.

The next sections describe how each construct in the conceptual framework was operationalized. The constructs are discussed in the same order as in the hypotheses. Table 5.2 presents the names of the variables and their respective sources. Appendix 5 provides a measurement summary with all variable names and their items.

5.3.1 Measurement of new product outcomes

NPD performance

The NPD performance measure was based on the 16 core items for measuring new product success from Griffin and Page (1993, 1996) and Hultink and Robben (1995). Respondents were asked to assess new product performance relative to objectives. The 16 measurement items referred to customer acceptance, product level, and financial performance dimensions.

Product advantage

Product advantage was measured with 10 items adapted from Cooper and Kleinschmidt (1987), Maidique and Zirger (1984), and Song and Parry (1997). All items referred to the new product's superiority over competing products in the eyes of the customer. As customer

ratings of product advantage were not available, respondents were asked to rate product advantage from their customers' perspectives (cf. Calantone and di Benedetto 1988).

Table 5.2: Variables in the survey research instrument and their sources

Variable name	**Source**
New product outcomes	
NPD performance	Griffin and Page (1993, 1996), Hultink and Robben (1995)
Product advantage	Cooper and Kleinschmidt (1987), Maidique and Zirger (1984), Song and Parry (1997)
Market information processing	
Use of market information	Newly developed, based on Deshpandé (1982), Deshpandé and Zaltman (1982), Menon and Varadarajan (1992), Ruekert (1992)
Dissemination of market information	Jaworski and Kohli (1993)
Acquisition of market information	Jaworski and Kohli (1993)
Project urgency characteristics	
Project priority	Newly developed, based on interviews, Cooper et al. (2000), and Ottum and Moore (1997)
Time pressure	Sethi (2000)
Company structural characteristics	
Formalization	Jaworski and Kohli (1993)
Centralization	Jaworski and Kohli (1993)
Interdepartmental conflict	Matsuno et al. (2002)
Company cultural characteristics	
Cultural Market Orientation	Deshpandé and Farley (1998)
Entrepreneurial orientation	Matsuno et al. (2002)
R&D Dominance	Newly developed, based on interviews and Workman (1993, 1998)
Willingness to cannibalize	Chandy and Tellis (1998)

5.3.2 Measurement of market information processing variables

Use of market information

The use of market information was defined in chapter 1 as taking information about current and future needs of customers and external factors that impact those needs into account when making NPD decisions (see also Veldhuizen et al. 2006). For measuring the use of market information in different stages of new product development new items were developed based on the work of Deshpandé (1982), Deshpandé and Zaltman (1982), Menon and

Varadarajan (1992), and Ruekert (1992). Deshpandé (1982) defined and operationalized the use of market research information in terms of whether a decision could have been made without market information or whether decisions would have been different if market information was considered. Deshpandé and Zaltman (1982) investigated factors affecting the use of market research information by marketing managers and referred to the use of information as solving a particular problem or making a particular decision. Ruekert (1992) identified the use of market information as a subscale of market orientation that captured issues such as improving the quality of products based on market information, and setting objectives based on customer needs.

In the present research project, respondents were asked to indicate to what extent they used market information in each of three generic stages of new product development. Questions about the use of market information were preceded by a description of the three generic stages of the new product development process: predevelopment, development and commercialization. Predevelopment was defined as the phase containing strategic planning, business and market opportunity analysis, and new product idea generation and evaluation. The development stage was defined as the development and testing stage of new product concepts, prototypes and the product design. Finally, the commercialization stage was defined as the phase where product specifications are released to manufacturing and the sales force is trained. Market introduction of the new product is prepared and decisions on launch strategies and tactics are made. In this stage the product is introduced into the market. After the introduction to these generic stages of new product development, respondents were asked to indicate on a 5-point Likert-type scale to what level they agreed or disagreed with statements on the extent of use of market information in each of the three stages. Market information use was measured with eight items referring to decision-making, problem solving, evaluating and improving the new product based on market information. Since these items were asked for each of the three stages, respondents had to answer 24 items on the use of market information.

Dissemination of market information

The dissemination of market information was measured with eight items that were adapted from the intelligence dissemination subscale for market orientation by Jaworski and Kohli (1993). Similar to the acquisition of market information, items for disseminating market information at the business unit level were adapted to the NPD project level. Items referring to a specific department in the organization were changed into items that were applicable to the NPD project team. For example, one original item about the communication between departments at the business unit level was changed into communication between project members during the NPD project.

Acquisition of market information

The acquisition of market information was measured with 10 items adapted from the intelligence generation subscale for market orientation by Jaworski and Kohli (1993). The original items referring to an organizational business unit were adapted to the NPD project level. Respondents were asked to indicate to what extent they agreed or disagreed with statements on how frequently and in which ways customer, competitor, and environmental information was acquired during the selected NPD project. Items that referred to a specific department at the business unit level in the original scale were changed into items that were applicable to the NPD project team.

5.3.3 Measurement of project urgency characteristics

Project priority

Project priority was measured with five items referring to the importance of the project to the company, the status of the project within the company, and the amount of resources available for the project. The items were newly developed based on the exploratory interviews with practitioners (see Chapter 3) and previous conceptualizations by Cooper et al. (2000) and Ottum and Moore (1997). From the interviews it was learned that project priority referred to the importance of a project and the allocation of resources. Cooper et al. (2000) discussed project prioritization in the context of portfolio management and concluded that most companies have too many projects for the limited resources available. Ottum and Moore (1997) defined project priority as full-time dedication to the project of project team members. Together, these findings were used as input for the generation of new items for the construct of project priority.

Time pressure

Time pressure during the NPD project was measured with four items that were adapted from Sethi (2000). Time pressure referred to the extent to which team members believed they had a shortage of time (Sethi 2000). Respondents were asked to indicate to what extent they agreed or disagreed with statements on the amount of time pressure felt during the selected NPD project.

5.3.4 Measurement of company structural characteristics

According to Deshpandé and Zaltman (1982), two methods can be used for measuring structural characteristics at the company level. One method examines the formal organization as described by a company's organizational chart, for example, by measuring the managerial span of control or the distribution of employees across functional areas (Blau and Schoenherr 1971). However, this approach has been criticized for producing measurements with a low

internal reliability, and they may be difficult to use in survey research (Seidler 1974). A different approach, which is adopted in this research project, uses the responses to questionnaire items asking respondents to indicate to what extent they agree or disagree with statements about the degree of formalization, centralization and interdepartmental conflict (Aiken and Hage 1968).

Formalization

The degree of formalization was measured at the company level with seven items adapted from Jaworski and Kohli (1993). Formalization has previously been defined as the degree to which standardized rules and procedures describe how activities are to be performed. To reflect this conceptualization, the formalization scale assessed the extent to which employees were free to make decisions, and the extent to which there was an emphasis on following rules and procedures.

Centralization

The degree of centralization was measured at the company level with five items adapted from Jaworski and Kohli (1993). Centralization refers to the concentration of decision-making authority at a higher level of the company's hierarchy (Jaworski and Kohli 1993, Moorman et al. 1993). Aligned with this conceptualization, the centralization scale assessed the extent to which decisions and important actions needed the approval of superiors.

Interdepartmental conflict

Interdepartmental conflict was measured at the company level with six items adapted from Matsuno et al. (2002). The construct was conceptualized as the tension between two or more departments that arises from those departments having divergent goals and a functional rather than an organizational perspective. The measurement items pertained to the extent to which the goals of different departments were incompatible and to the tension that existed in interdepartmental interactions.

5.3.5 Measurement of company cultural characteristics

The third set of antecedents, company cultural characteristics, is a mix of four factors at the firm-level derived from the interviews with practitioners and the extant literature: market orientation, entrepreneurial orientation, R&D dominance, and willingness to cannibalize.

Cultural market orientation

Cultural market orientation was measured at the company level with a 10-item scale adapted from Deshpandé and Farley (1998). The scale integrates the three separate scales of a firm's

market orientation that were originally developed by Narver and Slater (1990), Kohli et al. (1993), and Deshpandé, Farley and Webster (1993). Based on a study of 82 managers in 27 European and U.S. companies, Deshpandé and Farley (1998) compared the three scales by examining the inter-scale and intra-scale characteristics. Their results showed that the three scales are interchangeable and can be used together. Factor analysis reduced the total number of original items (44) to a more manageable size (10 items). The remaining items in the summary scale referred to the set of activities and cross-functional processes aimed at creating and satisfying customers.

Entrepreneurial orientation

Entrepreneurial orientation was measured at the company level with seven items adapted from Matsuno et al. (2002). The strategic management and entrepreneurial literatures showed that entrepreneurial orientation is distinguished by three underlying dimensions: the degree of innovativeness, risk taking and proactiveness (Covin and Slevin 1989, Miller 1983). This means that entrepreneurial orientation is a second-order construct in which the three underlying dimensions represent the first-order factors. Matsuno et al. (2002) developed items for the three dimensions of entrepreneurial orientation and empirically validated this second-order factorial structure. Thus, the final measurement items for entrepreneurial orientation reflect the three underlying dimensions and refer to the encouragement of creativity, risk taking behavior, and the exploration of opportunities.

R&D dominance

R&D dominance was measured at the company level with five items that were newly developed based on the exploratory interviews and by drawing on prior research (Workman 1993, 1998). High-tech firms often place a high value on people with technical skills and provide a high status to technical personnel (Workman 1998). In high-tech firms, R&D often becomes a dominant function with a large influence on new product development decisions (Workman 1993). In a participant observation study Workman (1993) found that most vice presidents and senior managers in a high-tech firm had technical backgrounds, which enabled the power and influence of engineering over other functions. Furthermore, the exploratory interviews revealed that companies with a dominant R&D function had a large number of technical employees and product managers with a technical background, compared to the number of employees in marketing for example. The measurement items for R&D dominance combined these insights and referred to the higher status of technical employees, the dominance of R&D in decision making, and the technical background of management and other employees.

Willingness to cannibalize

The final company cultural characteristic, willingness to cannibalize was measured with eight items adapted from Chandy and Tellis (1998). Willingness to cannibalize refers to the extent to which firms are prepared to give up the old and embrace the new, and the extent to which a firm is prepared to reduce the value of past investments (Chandy and Tellis 1998). Measurement items referred to how easily business units can change their organization to fit the needs of a new product, to what extent new products or technologies are supported that can take away from sales of existing products, and to what extent new technologies are pursued that can make existing investments lose value or make manufacturing facilities obsolete.

5.4 Mail survey

5.4.1 Survey administration

In administering the main mail survey, the total design method for survey research was followed (Dillman 1978). The single-informant method was used for data collection. Although the use of single informants has several important limitations (as will be discussed in chapter 7), it is a cost-efficient approach that is common practice in NPD research (e.g., Gatignon and Xuereb 1997, Moorman 1995). Companies were contacted through phone calls to gain commitment to participate and to identify the most suitable informant. Key-informants were responsible for and had been involved in the development project of a recently introduced innovative product. The questionnaire asked respondents to select the most innovative product developed and introduced by the company in the last three years.

The unit of analysis for the new product outcomes, market information processing variables and project urgency variables was the new product development project. The company structural characteristics and company cultural characteristics were measured at the company level. This procedure was chosen because several authors have called for multilevel research on innovation as it leads to an enhanced understanding of the factors leading to higher innovation performance (Atuahene-Gima and Ko 2001, Drazin and Schoonhoven 1996). Innovation studies tend to focus on a single organizational level such as the NPD project or the department. However, the interdependence of the various levels in organizations must be studied if a more complete understanding of these structures is to be achieved.

By combining project level and company level variables, this research attempts to clarify the relationships between market information processing during NPD projects and several antecedents at different levels of the organization. However, multilevel data that investigates the relationships between variables at different levels of an organization may pose several analytical problems (Molleman 2005, Osborne 2000).

For example, when multilevel data are gathered within one organization, respondents may be more similar to each other than when randomly selected. Because respondents in one organization may share certain characteristics (e.g., same culture, same leaders) observations based on these respondents are not independent, whereas most analytical techniques require independence of observations. Since data in the present research are not gathered within one organization but with key-informants across different organizations, independence of observations becomes a less critical issue.

Another problem with multilevel research refers to the direction of the relationships that have been specified. Multilevel research needs to address how phenomena at different levels are linked. Variables at a higher level (such as the company level) may have an effect on variables at a lower level (such as the NPD project level). On the other hand, the direction may also be reversed, as many organizational phenomena are created by individual or group behavior. This research adopts a top-down approach (Kozlowski and Klein 2000) by specifying company structural and company cultural characteristics as antecedents of market information processing at the NPD project level. An organizational structure is considered an antecedent variable because it defines how tasks are formally divided, grouped and coordinated. The direction of the company cultural relationships follows from the definition of company culture as the pattern of shared values and beliefs that provide individuals with norms for behavior in the organization.

A third difficulty with multi-level research refers to the measurement of company level characteristics by key-informants. For example, in this research individuals are asked to report on their perceptions of an organization's culture. These responses may not capture the collective properties of organizational climate. Furthermore, respondents may not be eager to share their opinion about certain (negative) characteristics of an organization.

While developing the survey research instrument, several attempts were made to reduce problems with multi-level variables. For example, all company-level variables were grouped together and their items were phrased so that they reflected organizational properties at the company level. In addition, the research instrument emphasized that the confidentiality of respondents' answers was guaranteed and that the responses were obtained explicitly for research purposes.

5.4.2 Sampling procedure

The REACH (Review and Analysis of Companies in Holland) directory of companies was used to develop a sample frame of 1,281 manufacturing companies in high-tech industries. In a period of six weeks, starting in November 2002, a team of five research assistants identified and pre-notified 550 potential respondents by phone and then sent each of them the questionnaire by mail. Potential respondents and the companies they worked for had to meet

two criteria to participate: The company had developed and introduced a new product in the last three years, and the respondent was responsible for and had been involved in the development project of a recently introduced innovative product. This step found that 61 companies were double listed in the sample frame, reducing the sample to 1,220 companies. Furthermore, the contact information of 291 companies appeared to be outdated as it was not possible to reach them by telephone, either because they had gone bankrupt or changed addresses. Another 174 companies in the sample did not qualify for the research as they had not developed products in the Netherlands. In addition, 120 companies were excluded from the sample because they developed services rather than physical products. In total, 67 companies indicated that they had not recently introduced a new product in the market. Therefore, the final sample consisted of 1220 - 652 = 568 companies. In the final sample, 83 companies did not want to participate in the research because they were too busy or not interested. As 33 companies agreed to participate in the research with more than one NPD project 550 questionnaires were distributed.

Potential respondents received a personalized letter explaining the purpose of the study, a questionnaire, and a preaddressed, postage paid envelope. As an incentive, respondents could indicate whether they wanted to receive a summary of the research findings. Over 81% did, indicating the relevance of this research to the respondents. Non-respondents were phoned after two weeks to ask if they had received the questionnaire and to remind them of the importance of their cooperation. This step showed that the research instrument was not applicable for 12 respondents as their firms had not introduced an innovative product in the past three years. In addition, these reminder phone-calls learnt that 25 questionnaires would not be returned because targeted respondents were no longer with the firm, due to time pressures or due to a policy of company confidentiality. After three weeks a reminder postcard was mailed to non-respondents. These efforts resulted in 187 returned questionnaires. However, not all the responses were usable as some of them contained too many missing values. Questionnaires with more than 5% missing values on the items, or more than 50% missing items on one multi-item construct were discarded. For example, if a questionnaire contained a five-item measure with only two items completed, the questionnaire was discarded. After this step, 166 completed questionnaires remained, for an effective response rate of 31.3%. To ensure respondent suitability, respondents were questioned on their knowledge about the project in question (Kumar, Stern and Anderson 1993). On a five-point scale, the mean response was 4.42 (sd = .68), showing evidence of sufficient knowledge.

5.4.3 Sample characteristics

The main goal of this research is 'to develop a better understanding of the role that market information processing plays during the development process of high-tech products' (chapter 1, p. 11). Particularly in high-technology industries, market information processing has been identified as a problematic area (Mohr et al. 2005). For this reason, the mail survey was aimed at NPD managers of companies in high-tech industries.

Targeted industries included chemicals, electrical and industrial machinery, electronics, medical appliances and optical instruments, and information technology. Similar industries have been used in previous research on high-tech firms. For example, Gupta, Raj and Wilemon (1985) collected data on new product development activities of high-tech firms in the chemical, electrical, electronics, information processing, instrumentation, semiconductors, and telecommunications industries.

Table 5.3 shows the sample characteristics. Most companies were operating in the electrical and industrial machinery industry (47.6%). This industry was also overrepresented in the sample frame (42.5%), suggesting that most high-tech firms in the Netherlands are found in the electrical and industrial machinery industries. The number of employees in the sampled companies ranged between 3 and 8000 employees. Over 80% of the companies had more than 50 employees. Company sales varied between 350,000 Euro and 2.8 billion Euro. The average number of employees across all companies was 256 and average company sales were 78.6 million Euro. The majority of the respondents came from the R&D (37.9%) or Marketing/Sales functions (24.7%).

Table 5.3: Sample characteristics (n=166)

Industry		**Number of employees**		**Sales in Euro's ($x\ 10^6$)**		**Respondents**	
Chemicals	14.9%	< 51	19.9%	<2	5.7%	General management	15.1%
Electr. & Ind. Machinery	47.6%	51-75	16.8%	2-6	13.7%	Marketing/Sales	24.7%
Electronics	13.4%	76-100	14.9%	6-10	13.0%	R&D	37.9%
Medical Appl. & Opt. Instr.	10.2%	101-150	21.7%	10-15	15.0%	Production	16.9%
Information Technology	13.9%	151-300	16.8%	15-25	16.5%	Finance	.6%
	100.0%	> 300	9.9%	25-50	16.0%	Other	4.8%
			100.0%	51-100	12.2%		100.0%
				>100	7.9%		
					100.0%		

In addition to these general sample characteristics, the questionnaire contained specific items on the R&D/market research budget, target market, NPD cycle-time and product representativeness. Responding companies spent on average 7.1% of sales on R&D and 1.9% of sales on market research. Almost 75% of the responding companies were active in business-to-business markets. The cycle-time for developing new products ranged from 2

months to 80 months and the average cycle-time was 18.6 months. As a comparison, the 1995 PDMA Best Practices study found that “more innovative” products had an average cycle time of about 18 months (Griffin 1997), providing support that the sample investigated here is a set of “more innovative” products. The products that were selected are representative for the products that the companies develop and introduce to the market. On average they scored 4.1 on a 5-point scale ranging from ‘not representative at all’ to ‘very representative’.

Non-response bias was evaluated by comparing early respondents (28.3% of the sample) with late respondents (25.9% of the sample) as recommended by Armstrong and Overton (1977). The early group responded in less than 10 days, whereas the group of late respondents needed more than 38 days to respond. A comparison of the two groups did not reveal any significant differences in the constructs presented in the conceptual framework. Table 5.4a presents the results of this comparison. In addition, the annual sales levels and the number of employees were compared between responding and non-responding firms in the REACH directory. Neither t-test was significant, suggesting that non-response bias is not a major problem.

One potential danger of using single-informants in survey research is its vulnerability to respondent bias (Ernst and Teichert 1998). To evaluate respondent bias the responses obtained from persons with different functional backgrounds (e.g., marketing, production, R&D) were compared with one-way ANOVA’s and post-hoc Scheffé tests. Table 5.4b presents the results of these comparisons. No significant differences emerged suggesting that respondent bias was not a major problem. To evaluate potential biases of company size, the responses of large, medium and small companies were compared. Three groups were created (ranging from small to large companies) and a one-way ANOVA with post-hoc Scheffé tests on all the variables were performed. Small companies were defined as companies with 1 through 70 employees (33.5%), medium companies with 71 through 140 employees (30.5%) and large companies had over 140 employees (36%). Table 5.4c presents the results of these comparisons. Again, no significant differences emerged, suggesting that company size bias was not a problem.

Since data on the independent and dependent variables were collected from the same informant there is a potential for common method bias. Exploratory factor analysis assessed common method bias with Harman’s one-factor method (Podsakoff and Organ 1986). The principal components analysis with varimax rotation revealed 44 factors with eigenvalues greater than 1.0 accounting for 80.3% of the variance. Furthermore, the results indicated that the first factor did not account for a majority of the variance (13.7%) and there was no general factor in the unrotated factor structure, suggesting that common method bias was not a major problem.

Table 5.4a: Comparison of early versus late respondents

	Mean values of early respondents (n=47)	Mean values of late respondents (n=43)	T-Value	p-value
New product outcomes				
Market/Financial Success*	3.12	3.13	.09	.93
Time/Cost Efficiency*	3.31	3.02	1.32	.19
Product Advantage	3.76	3.83	.48	.64
Market Information Processing				
Use of Market Information in Predevelopment	3.26	3.25	.08	.94
Use of Market Information in Development	3.07	3.26	1.12	.27
Use of Market Information in Commercialization	2.97	3.13	.86	.39
Dissemination of Market Information	2.65	2.86	1.31	.20
Acquisition of Environmental Information*	3.02	2.83	1.15	.25
Acquisition of Customer Information*	2.88	3.05	1.08	.28
Project Urgency Characteristics				
Project Priority	3.70	3.72	.16	.87
Time pressure	2.81	2.98	.92	.36
Company Structural Characteristics				
Formalization	3.59	3.70	.85	.40
Centralization	2.37	2.42	.41	.68
Interdepartmental Conflict	2.75	2.63	.94	.35
Company Cultural Characteristics				
Implementing Cultural Market Orientation*	3.56	3.65	.55	.58
Measuring Cultural Market Orientation*	2.75	2.97	1.14	.26
Entrepreneurial Orientation**	-	-	-	-
R&D Dominance	3.37	3.64	1.42	.16
Flexibility to New Products*	3.19	3.41	1.50	.22

* New variable names after scale purification.
** Psychometrically invalid measure, therefore dropped.

Table 5.4b: Evaluation of respondent bias

	Mean for general management (n=25)	Mean for marketing/ sales (n=41)	Mean for R&D (n=63)	Mean for production (n=28)	p-value
New product outcomes					
Market/Financial Success*	3.13	3.37	3.20	3.09	.66
Time/Cost Efficiency*	3.46	2.96	3.13	3.14	.25
Product Advantage	3.98	4.09	3.92	3.48	.06
Market Information Processing					
Use of Market Information in Predevelopment	2.95	3.24	3.39	3.04	.21
Use of Market Information in Development	3.12	3.16	3.25	3.04	.72
Use of Market Information in Commercialization	3.04	3.23	3.28	2.88	.25
Dissemination of Market Information	2.72	2.85	2.77	2.64	.72
Acquisition of Environmental Information*	2.84	3.04	3.08	2.73	.30
Acquisition of Customer Information*	2.88	3.09	2.99	2.84	.58
Project Urgency Characteristics					
Project Priority	3.37	3.72	3.69	3.33	.24
Time pressure	3.12	3.18	3.25	2.96	.58
Company Structural Characteristics					
Formalization	3.85	3.68	3.66	3.65	.71
Centralization	2.15	2.29	2.22	2.24	.85
Interdepartmental Conflict	2.78	2.83	2.76	2.81	.98
Company Cultural Characteristics					
Implementing Cultural Market Orientation*	3.83	3.43	3.72	3.60	.17
Measuring Cultural Market Orientation*	2.96	2.83	2.87	2.96	.95
Entrepreneurial Orientation**	-	-	-	-	-
R&D Dominance	3.61	3.44	3.43	3.63	.84
Flexibility to New Products*	3.21	2.94	3.00	3.08	.55

* New variable names after scale purification.
** Psychometrically invalid measure, therefore dropped.

Table 5.4c: Evaluation of company size bias

	Mean for small size (n=54)	Mean for medium size (n=49)	Mean for large size (n=58)	p-value
New product outcomes				
Market/Financial Success*	3.24	3.19	3.15	.88
Time/Cost Efficiency*	3.28	3.12	3.03	.46
Product Advantage	3.88	3.92	3.93	.93
Market Information Processing				
Use of Market Information in Predevelopment	3.12	3.30	3.19	.52
Use of Market Information in Development	3.06	3.26	3.17	.39
Use of Market Information in Commercialization	3.04	3.27	3.11	.35
Dissemination of Market Information	2.79	2.76	2.73	.92
Acquisition of Environmental Information*	2.99	2.93	2.98	.94
Acquisition of Customer Information*	2.94	2.88	3.04	.54
Project Urgency Characteristics				
Project Priority	3.65	3.41	3.61	.29
Time pressure	3.09	2.96	3.34	.06
Company Structural Characteristics				
Formalization	3.59	3.71	3.70	.69
Centralization	2.25	2.21	2.13	.65
Interdepartmental Conflict				
Company Cultural Characteristics				
Implementing Cultural Market Orientation*	3.67	3.65	3.56	.75
Measuring Cultural Market Orientation*	2.94	2.93	2.75	.55
Entrepreneurial Orientation**	-	-	-	-
R&D Dominance	3.40	3.73	3.44	.16
Flexibility to New Products*	3.10	2.97	3.02	.68

* New variable names after scale purification.
** Psychometrically invalid measure, therefore dropped.

5.5 Measure validation

Measure validation refers to the assessment of the psychometric properties of measurement scales and the purification of those scales based on certain criteria. The next section defines five psychometric properties of measurement scales and describes how they can be determined. Section 5.5.2 presents the psychometric properties of the measurement scales that are used in this research.

5.5.1 Psychometric properties

Reliability and validity are two important psychometric properties of a measurement scale. Reliability refers to the accuracy or precision of a measurement instrument (Kerlinger 1986). Before the reliability of a measurement scale can be determined, its unidimensionality should be assessed (Steenkamp and van Trijp 1991). Validity indicates the degree to which an instrument measures the construct under investigation and can be broken down into content validity, convergent validity and discriminant validity (Kerlinger 1986). Therefore, the following psychometric properties can be distinguished that need to be assessed for measure validation: (1) unidimensionality, (2) reliability, (3) content validity, (4) convergent validity and (5) discriminant validity. These five psychometric properties are discussed below.

(1) Unidimensionality refers to the existence of one construct underlying a set of items (Anderson, Gerbing and Hunter 1987). Unidimensionality can be inspected with EFA by determining the eigenvalue and factor loadings (Sharma 1996). Item-to-total correlations may help decide which items should be retained in order to obtain a unidimensional measure. In addition, CFA can be used to ensure unidimensionality by investigating factor loadings and overall model fit (Steenkamp and van Trijp 1991).

(2) Reliability can be defined as the degree to which measures are free from error and therefore yield consistent results (Peter 1979). Reliability can be measured with Cronbach's coefficient alpha which should surpass the .70 threshold recommended by Nunnally (1978) for confirmatory research. High Cronbach's alphas refer to patterns of high inter-correlations among the items in a scale, indicating that they constitute a coherent whole in measuring a construct. Another indicator for reliability based on CFA is the composite reliability. This indicator should be over .60 (Bagozzi and Yi 1988).

(3) Content validity refers to whether the measurement instrument represents the underlying construct (Churchill 1999). Based on classical test theory, this research project uses reflective measures, where items are perceived as reflective indicators of an underlying construct (Bollen and Lennox 1991). This means that the causal relationships run from the constructs to the items. An alternative measurement perspective is based on formative indicators where the items are assumed to cause a latent variable (Bollen 1989). Unlike formative indicators, reflective indicators are interchangeable. Thus, the removal of a

reflective item does not change the essential nature of the underlying construct (Diamantopoulos and Winkelhofer 2001). Content validity of reflective measures can be determined by checking the extent to which the content of the items is related to the construct they intend to measure. This may be done by a researcher or a panel of other experts.

(4) Convergent validity is indicated by the fact that in each model the items load significantly on the corresponding latent construct. Convergent validity can be assessed by performing a series of CFA's taking one scale at a time (Baumgartner and Homburg 1996). The criterion of all factor loadings being significant at the 0.05 level can be used as the indicator of convergent validity (Bagozzi and Phillips 1991). Furthermore, composite reliability and average variance extracted can be used to determine convergent validity. To be considered adequate, composite reliability should be greater than 0.60 and the average variance extracted should be at least 0.50 (Bagozzi and Yi 1988).

(5) Discriminant validity means that 'one can empirically differentiate the construct from other constructs that may be similar and that one can point out what is unrelated to the construct' (Kerlinger 1986). This implies that if two or more constructs are unique, then valid measures of each should not correlate too highly (Bagozzi and Phillips 1991). Discriminant validity can be determined with CFA by using a chi-square-difference test (Anderson and Gerbing 1988). This test involves the analysis of all possible pairs of constructs in a single construct and a two-construct model. In the single construct model, the correlation between the constructs is constrained to unity. This implies that the items of the two constructs are treated as if they were one construct. In the two-construct model the parameters are set free, which means that the items load on their corresponding constructs. When the chi-square of the two-construct model is significantly lower than the chi-square of the single construct model, discriminant validity of the two constructs is demonstrated.

CFA is a 'powerful tool' to determine the psychometric properties of measurement scales (Steenkamp and van Trijp 1991, p.284). The adequacy of CFA models for measure validation can be compared with several fit indices: the chi-square divided by degrees of freedom, the root mean square error of approximation (RMSEA), the goodness-of-fit index (GFI), the normed fit index (NFI), the non-normed fit index (NNFI), the comparative fit index (CFI), and the incremental fit index (IFI). These fit indices complement each other in assessing the fit of the data to the model (Bentler and Bonett 1980). The chi-square measure is the traditional fit index normally used to see how well the model fits the population. Non significance of the chi-square indicates a good model fit. However, the sensitivity of the chi-square to the sample size can lead to problems (Byrne 1998). Furthermore, the chi-square statistic assumes that the model fits the population perfectly, which by definition is not true as a model is only an approximation of reality (Diamantopoulos and Siguaw 2000). The degrees

of freedom should therefore be taken into account. A model with a good fit is indicated by a chi-square value that approximates the degrees of freedom (Jöreskog and Sörbom 2005). A second measure that can be used to evaluate model fit is the root mean square error of approximation (RMSEA). This measure focuses on the discrepancy between the observed and implied covariance matrix and takes model complexity into account (Diamantopoulos and Siguaw 2000). Values less than 0.05 are indicative of good fit, between 0.05 and under 0.08 of reasonable fit, between 0.08 and 0.10 of mediocre fit and >0.10 of poor fit (Browne and Cudeck 1993).

Besides these traditional measures of model fit, the present research also uses other measures of absolute and relative model fit. The goodness-of-fit index (GFI) is an absolute fit measure and indicates the relevant amount of covariances accounted for by the model. Values of the GFI range between 0 and 1 and values >0.90 are usually taken as reflecting acceptable fit (Jöreskog and Sörbom 2005). Measures of relative model fit, such as the normed fit index (NFI), non-normed fit index (NNFI), comparative fit index (CFI) and incremental fit index (IFI) depend on the relative comparison with a more restricted baseline model, usually the independence model (Bentler and Bonett 1980, Bollen 1989, Jöreskog and Sörbom 2005). The independence model is a model that specifies that all measured variables are uncorrelated. With the exception of the non-normed fit index (NNFI), all the indices in this group have a range between 0 and 1 with values close to 1 representing good fit (the NNFI can take values greater than 1).

The normed fit index (NFI), also known as Bentler-Bonett normed fit index reflects the proportion by which the model improves fit compared to the independence model. However, NFI is sensitive to the number of parameters in a model. If more parameters are added to the model, NFI becomes larger (James, Mulaik and Brett 1982). The non-normed fit index measures relative fit by comparing noncentrality per degree of freedom, but may be sensitive to sample size (Bentler 1990, Bollen 1990). The comparative fit index (CFI) avoids the underestimation of fit in small sample sizes (Bentler 1990). CFI compares the covariance matrix predicted by the model and the independence model to the observed covariance matrix. The incremental fit index (IFI) provides an adjustment to the NFI for sample size and degrees of freedom (Bollen 1989).

5.5.2 Assessment of psychometric properties

The current section describes the assessment of the five psychometric properties: (1) unidimensionality, (2) reliability, (3) content validity, (4) convergent validity and (5) discriminant validity.

Following Steenkamp and van Trijp (1991), the dimensionality of each measure was explored with principal components analysis to investigate whether meaningful sub-factors

were present in the data. First, the suitability of the dataset for factor analysis was tested as recommended by Comrey (1978). For this procedure the Kaiser-Mayer-Olkin (KMO) measure was used. The significance of the KMO was indicated by Bartlett's test for sphericity. KMO values >.70 indicated that the data were suitable for factor analysis. Then, principal axis factoring explored the unidimensionality of each scale using an eigenvalue of 1.0 and factor loadings of .25 as the cutoff points (Steenkamp and van Trijp 1991). Both items with a factor loading below .25 and cross-loading items were dropped. The remaining items in each significant factor were subjected to a reliability analysis.

Based on the outcomes of the EFA procedures, the reliability coefficients of each unidimensional scale were computed. In addition, the inter-item correlations and corrected item-to-total correlations were examined. When coefficient alphas were below 0.7, items with the lowest corrected item-to-total correlation were removed.

These procedures showed that some of the constructs were more complex than initially hypothesized. Table 5.5 shows the results from the assessment of unidimensionality and reliability for new product outcomes, market information processing variables and the antecedents of market information processing.

Product development performance was more complex than originally theorized, resulting in two separate factors: market/financial success and time/cost efficiency. Market information acquisition split into customer and environmental information acquisition. Information acquired from customers concerns understanding customer problems while the environmental items measure collecting competitor and general industry information. While the literature suggests that this full breadth of information is necessary for a market orientation (Kohli and Jaworski, 1990), our research suggests that these two different components are collected differentially, and thus also may act differentially.

For the antecedent variables, cultural market orientation at the company level split into implementing cultural market orientation and measuring cultural market orientation. In the remainder of the analysis, these different dimensions are treated as distinct variables. The original measure for entrepreneurial orientation split into three dimensions, but each of the separate dimensions had a low coefficient alpha (Cronbach's alpha < .54) or low inter-item correlation (r < .20). In addition, a second-order factorial model in LISREL showed that the individual items did not load cleanly on the three separate dimensions. Therefore, the entrepreneurial orientation scale was removed from all further analyses.

Content validity of the measurement scales was determined in discussions with five academics who all were experts in the field of new product development. Inspection of the measurement items for willingness to cannibalize remaining after scale purification revealed that it was not so much the firm's willingness to cannibalize that now was measured, but a related construct called "the firm's flexibility to new products". A company that easily can

switch from one technology to another, and that supports NPD projects even if they can take away from sales of existing products, has flexibility to new products. In the remainder of this project, the original variable "willingness to cannibalize" will therefore be relabeled "flexibility to new products"[4].

The items remaining after the EFA procedures and reliability analyses were iteratively subjected to CFA for the assessment of convergent and discriminant validity. Before employing CFA, the distributional properties of the data were considered (Breckler 1990). Data were screened for potential outliers, distributions were plotted in a histogram and the skewness and kurtosis of individual items were examined. No severe deviations from normality were detected, suggesting that the data were appropriate for CFA. CFA was performed separately for the new product outcomes, the market information processing variables, and the antecedent variables. Three sets of antecedent variables were created to obtain a favorable respondent to items ratio. It was not possible to run a CFA on all measures in the study simultaneously because of sample size constraints (Bagozzi and Baumgartner 1994).

Convergent validity was assessed by performing a series of CFA's taking one scale at a time (Baumgartner and Homburg 1996). The criterion of all factor loadings being significant at the 0.05 level was used as the indicator of convergent validity (Bagozzi and Phillips 1991). Items that did not load significantly on a factor were deleted one by one, starting with the lowest factor loadings. Composite reliability was calculated using procedures outlined by Fornell and Larcker (1981). In addition, the average variance extracted was assessed for each construct (Anderson and Gerbing 1988).

The results, summarized in tables 5.6 and 5.7, indicate that all composite reliabilities exceed the .60 threshold level for acceptable composite reliability and that the majority of the values for average variance extracted exceed the threshold level of .50. The market information processing, formalization, and the implementation of market orientation variables did not meet the requirements for average variance extracted, indicating that measurement error accounts for a greater amount of variance in the indicators than does the underlying latent variable. As the items for the use of market information were the same in each of the three stages of new product development, it was not surprising to find that the error terms were correlated. In LISREL all error terms are assumed to be uncorrelated by default (Jöreskog and Sörbom 2005). Therefore a measurement model was specified with correlated error terms for the information use items. This resulted in a CFA model with a good fit (Chi^2/df=1.40; GFI=.86; NFI=.84; NNFI=.93; CFI=.94; IFI=.94; RMSEA=.049).

[4] Perhaps, as one committee member rightfully suggested, the term "technology agility" is a more appropriate name for this construct. The term "flexibility to new products" is maintained, however, because new technologies should ultimately be applied in new products.

Table 5.5: Assessments of unidimensionality and reliability (n=166)

	Mean*:	SD:	# items remaining:	Lowest item-item correlation:	Lowest item-total correlation:	Cronbach's alpha:	Eigen-value:
New product outcomes							
Market/Financial Success	3.21	.91	4	.71	.59	.92	3.26
Time/Cost Efficiency	3.15	1.01	2	.54	.54	r=.54	1.54
Product Advantage	3.92	.70	4	.38	.52	.80	2.51
Market Information Processing							
Use in Predevelopment	3.23	.86	4	.37	.49	.74	2.24
Use in Development	3.19	.77	4	.31	.42	.71	2.13
Use in Commercialization	3.15	.81	4	.25	.42	.71	2.17
Dissemination of Market Information	2.78	.75	4	.31	.43	.74	2.25
Acquisition of Env. Information	2.99	.78	4	.35	.44	.75	2.32
Acquisition of Cust. Information	2.99	.77	4	.31	.43	.71	2.15
Project Urgency Characteristics							
Project Priority	3.59	.79	4	.54	.67	.86	2.81
Time pressure	3.15	.85	3	.55	.62	.81	2.18
Company Structural Characteristics							
Formalization	3.68	.70	3	.39	.44	.71	1.91
Centralization	2.20	.66	3	.35	.51	.74	1.97
Interdepartmental Conflict	2.78	.73	5	.42	.60	.85	3.09
Company Cultural Characteristics							
Implementing Cultural MO	3.63	.75	3	.42	.51	.72	1.93
Measuring Cultural MO	2.89	.90	4	.42	.61	.83	2.64
Entrepreneurial Orientation**	-	-	0	-.20	.07	.58	2.09
R&D Dominance	3.51	.88	4	.45	.53	.81	2.58
Flexibility to New Products	3.05	.79	3	.42	.52	.74	1.98

* Entries are based on a 5-point scale with '1' = completely disagree and '5' = completely agree.
** Psychometrically invalid measure, therefore dropped.

Table 5.6: Assessments of convergent validity for market information processing and new product outcomes

	Lowest t-value	Average variance extracted	Composite reliability
New product outcomes			
Market/Financial Success	12.22	.75	.92
Time/Cost Efficiency	5.28	.54	.70
Product Advantage	7.83	.51	.81
Evaluation model: Chi^2/df=1.45; GFI=.95; NFI=.95; NNFI=.98; CFI=.98; IFI=.98; RMSEA=.052			
Market Information Processing			
Use of Market Information in Predevelopment	8.18	.41	.74
Use of Market Information in Development	7.01	.37	.70
Use of Market Information in Commercialization	7.55	.40	.72
Acquisition of Environmental Information	6.55	.45	.76
Acquisition of Customer Information	5.85	.39	.71
Dissemination of Market Information	6.56	.43	.74
Evaluation model: Chi^2/df=1.40; GFI=.86; NFI=.84; NNFI=.93; CFI=.94; IFI=.94; RMSEA=.049			

Table 5.7: Assessments of convergent validity for antecedents of market information processing

	Lowest t-value	Average variance extracted	Composite reliability
Project Urgency Characteristics			
Project Priority	10.06	.60	.86
Time pressure	9.31	.59	.81
Evaluation model: Chi^2/df=2.28; GFI=.95; NFI=.95; NNFI=.96; CFI=.97; IFI=.97; RMSEA=.088			
Company Structural Characteristics			
Formalization	6.02	.47	.72
Centralization	7.54	.51	.75
Interdepartmental Conflict	9.03	.52	.85
Evaluation model: Chi^2/df=1.25; GFI=.95; NFI=.91; NNFI=.97; CFI=.98; IFI=.98; RMSEA=.039			
Company Cultural Characteristics			
Implementing Cultural Market Orientation	7.03	.47	.72
Measuring Cultural Market Orientation	8.71	.55	.83
R&D Dominance	7.19	.54	.82
Flexibility to New Products	7.88	.49	.74
Evaluation model: Chi^2/df=1.65; GFI=.91; NFI=.87; NNFI=.92; CFI=.94; IFI=.94; RMSEA=.063			

Table 5.8a: Chi-square difference test for all possible pairs of new product outcomes

						1	2	3
New product outcomes								
1	Market/Financial Success					-		
2	Time/Cost Efficiency	**1-construct model**	**chi^2**	**=**		60.60	-	
			d.f.	**=**		9		
		2-construct model	**chi^2**	**=**		17.61		
			d.f.	**=**		8		
3	Product Advantage	**1-construct model**	**chi^2**	**=**		222.63	56.55	-
			d.f.	**=**		20	9	
		2-construct model	**chi^2**	**=**		23.25	7.91	
			d.f.	**=**		19	8	

Table 5.8b: Chi-square difference test for market information processing variables

					4	5	6	7	8	9
Market information processing variables										
4	Use in Predevelopment				-					
5	Use in Development	**1-construct model**	**chi^2**	**=**	238.69	-				
			d.f.	**=**	46					
		2-construct model	**chi^2**	**=**	201.53					
			d.f.	**=**	45					
6	Use in Commercialization	**1-construct model**	**chi^2**	**=**	248.69	266.68	-			
			d.f.	**=**	46	46				
		2-construct model	**chi^2**	**=**	195.21	224.97				
			d.f.	**=**	45	45				
7	Dissemination of	**1-construct model**	**chi^2**	**=**	568.50	605.43	593.41	-		
	Market Information		**d.f.**	**=**	100	100	100			
		2-construct model	**chi^2**	**=**	483.35	559.92	485.43			
			d.f.	**=**	99	99	99			
8	Acquisition of	**1-construct model**	**chi^2**	**=**	500.65	529.84	557.40	740.49	-	
	Environmental Information		**d.f.**	**=**	100	100	100	100		
		2-construct model	**chi^2**	**=**	417.57	497.41	437.43	694.13		
			d.f.	**=**	99	99	99	99		
9	Acquisition of	**1-construct model**	**chi^2**	**=**	551.47	558.95	555.45	734.41	732.27	-
	Customer Information		**d.f.**	**=**	100	100	100	100	170	
		2-construct model	**chi^2**	**=**	444.84	510.31	440.32	694.35	692.08	
			d.f.	**=**	99	99	99	99	169	

Table 5.8c: Chi-square difference test for project urgency characteristics

					10	11
Project urgency characteristics						
10	Project Priority				-	
11	Time Pressure	**1-construct model**	**chi^2**	=	186.60	-
			d.f.	=	14	
		2-construct model	**chi^2**	=	29.64	
			d.f.	=	13	

Table 5.8d: Chi-square difference test for company structural characteristics

Company structural characteristics					12	13	14
12	Formalization				-		
13	Centralization	**1-construct model**	**chi^2**	=	173.30	-	
			d.f.	=	14		
		2-construct model	**chi^2**	=	22.37		
			d.f.	=	13		
14	Interdepartmental Conflict	**1-construct model**	**chi^2**	=	109.42	139.27	-
			d.f.	=	20	20	
		2-construct model	**chi^2**	=	18.14	28.06	
			d.f.	=	19	19	

Table 5.8e: Chi-square difference test for company cultural characteristics

					15	16	17	18
Company cultural characteristics								
15	Implementing Cultural MO				-			
16	Measuring Cultural MO	**1-construct model**	**chi^2**	=	110.17	-		
			d.f.	=	14			
		2-construct model	**chi^2**	=	39.52			
			d.f.	=	13			
17	R&D Dominance	**1-construct model**	**chi^2**	=	116.51	320.59	-	
			d.f.	=	14	20		
		2-construct model	**chi^2**	=	13.57	38.66		
			d.f.	=	13	19		
18	Flexibility to New Products	**1-construct model**	**chi^2**	=	94.04	149.33	132.83	-
			d.f.	=	9	14	14	
		2-construct model	**chi^2**	=	7.38	33.98	27.92	
			d.f.	=	8	13	13	

Discriminant validity was assessed with a chi-square-difference test for each possible pair in each block of variables that was subjected to CFA. For all 28 chi-square-difference tests that were conducted, the two-construct model showed a better fit than the one-construct model (see table 5.8a-e). The smallest chi-square difference was 37.16, which is well above the critical value of the chi-square distribution with 1 degree of freedom (6.63; $p<.01$). Thus, the chi-square-difference tests are in support of the discriminant validity for all measures of the three blocks of antecedents, market information processing variables and new product outcomes.

5.6 Summary and conclusions

The current chapter showed how the mail survey research method was applied in this research project. The mail survey approach was used because it is an efficient approach to gather data on a large number of NPD projects for hypotheses testing. The mail survey procedure consisted of three stages: pilot interviews, a pilot survey, and the main survey. First, pilot interviews were conducted to refine measures and clarify ambiguities. The pilot interviews with nine NPD-managers indicated that the meaning of questions and answer categories were clear and that the survey research instrument could be completed without difficulty. Then, a pilot mail survey of 150 NPD-projects was conducted to test the measurement scale properties. The results from this pilot survey showed that the measures in the questionnaire were reliable and could be used in the main mail survey.

Most of the constructs in the questionnaire were measured with multiple-item measurement scales. Multi-item measures were predominantly drawn from the extant literature, but some had to be newly developed. A double translation procedure ensured that the content and meaning of the adopted measures remained the same in Dutch as they were in the original English.

The total design method for survey research was followed in administering the mail survey. From a sample frame of 1,281 companies in high-tech industries, 550 potential respondents were identified and pre-notified for receiving a questionnaire. Potential respondents were responsible for and had been involved in the development project of a recently introduced innovative product. Based on responses from 166 key-informants in the main mail survey, the measures were validated. A series of exploratory factor analyses, confirmatory factor analyses and reliability analyses were conducted to purify the measurement scales. Tables 5.9a-d present a summary of all constructs and their remaining items after measure validation.

After developing and validating the measurement scales in chapter 5, the conceptual framework can be specified empirically. Chapter 6 will use a path analysis approach to determine the extent to which the conceptual framework is consistent with the data.

Table 5.9a: Remaining items for market information processing variables and new product outcomes

Construct	Remaining items
Market/ Financial Success	The new product attains unit sales goals.
	The new product attains revenue growth goals.
	The new product attains market share goals.
	The new product attains sufficient sales as a percentage of total company sales.
Time/Cost Efficiency	The new product stayed under the development budget.
	The new product had a short 'time-to-market'.
Product Advantage	According to customers…
	the product had a higher quality than competing products.
	the product was more innovative than competing products.
	the product offered benefits that were not found in competing products.
	the product was superior to competing products.
Use of Market Information	In the stage predevelopment/development/commercialization….
	market information was used in evaluating the new product.
	market information had an influence on product-related decisions.
	market information was used in solving project-related problems.
	market information was used to segment the market for the new product.
Dissemination of Market Information	During the NPD project…
	employees spent time discussing customers' future needs.
	documents circulated periodically that provided information on our customers.
	in a short period everybody knew about it, when something important happened to a major customer or market.
	data on customer satisfaction were disseminated at all levels on a regular basis.
Acquisition of Customer Information	During the NPD project…
	project members met potential customers to learn how to serve them.
	a lot of market research was done.
	we were quick in detecting changes in our customers' product preferences.
	we polled endusers several times to assess the quality of our product.
Acquisition of Environmental Information	During the NPD project…
	we often talked with those who could influence our endusers purchases.
	intelligence on our competitors was generated by different departments.
	we were quick in detecting fundamental shifts in our industry.
	we periodically reviewed the likely effect of changes in our business environment on customers.

Table 5.9b: Remaining items for project urgency characteristics

Construct	Remaining items
Project Priority	Priority was given to the project over other projects.
	Management considered the project more important than other running projects.
	The project's success was of utmost importance to our company.
	The project had a high status for our company.
Time Pressure	During the NPD project…
	employees often wished they had more time to complete their work.
	employees believed they were under a lot of time pressure.
	meeting deadlines was every time a difficult task.

Table 5.9c: Remaining items for company structural characteristics

Construct	Remaining items
Formalization	How things are done around here is left up to the person doing the work. *
	Employees here are allowed to do almost as they please. *
	Most employees here make there own rules on the job. *
Centralization	Small matters have to be referred to someone higher up for a final answer.
	I have to ask my boss before I do almost anything.
	Any decision I make has to have my boss' approval.
Interdepartmental Conflict	In our business unit…
	employees feel that the goals of different departments are in harmony with each other. *
	protecting one's department turf is considered to be a way of life.
	there is little or no interdepartmental conflict. *
	different departments cooperate effectively to achieve mutual goals. *
	there is little or no tension among employees from different departments. *

* indicates a reversed item

Table 5.9d: Remaining items for company cultural characteristics

Construct	Remaining items
Implementing	Our business objectives are driven primarily by customer satisfaction.
Cultural MO	We constantly monitor our level of orientation to customers.
	Our strategy for competitive advantage is based on our understanding of customer needs.
Measuring	We measure customer satisfaction systematically and frequently.
Cultural MO	We have regular measures of customer service.
	We poll end users at least once a year to assess the quality of our products and services.
	Data on customer satisfaction are disseminated at all levels in this business unit on a regular basis.
R&D Dominance	In our business unit…
	we have a lot of technical employees.
	the majority of our managers has a technical background.
	top management mainly consists of technical people.
	technical employees have more influence on decisions than marketing employees.
Flexibility to	Our business unit…
New Products	supports projects even if they could potentially take away from sales of existing products.
	easily replaces one set of abilities with a different set of abilities to adopt a new technology.
	will pursue a new technology, even if it causes existing investments to lose value. *

* indicates a reversed item

Chapter 6 – Exploring the conceptual framework

This chapter describes an empirical specification of the conceptual framework with antecedents and consequences of market information processing in high-tech new product development. Path analysis is used to explore the hypotheses and to examine the relationships within the conceptual framework. The results provide initial answers to the question of whether market information processing is associated with new product outcomes during high-tech new product development and to what extent project urgency, company structural and company cultural characteristics are associated with market information processing. This chapter is structured as follows: First, section 6.1 explains the use of path analysis with maximum likelihood (ML) estimation. Then, section 6.2 presents the findings for the consequences of market information processing. Subsequently, section 6.3 describes the analyses for the antecedents of market information processing. Section 6.4 concludes with an analysis of the integrated model of relationships between antecedents and consequences of market information processing.

6.1 Path analysis with maximum likelihood estimation

The conceptual framework with antecedents and consequences of market information processing (as presented in chapter 4) describes the interrelationships among different dependent and independent variables. The complexity of these interrelationships suggests that a path analysis approach is needed to evaluate the model as a whole. Path analysis is a method that looks at more than one dependent variable at a time and allows for variables to be dependent with respect to some variables and independent with respect to others. Path analysis is a structural equation modeling (SEM) technique that deals with the relationships among observed variables only.

SEM is a statistical method for the analysis of relationships among both observed *and* unobserved variables. The use of SEM with unobserved variables is preferable to path analysis as it considers the degree of measurement error explicitly in the analysis (Hair, Anderson, Tatham and Black 1998). However, SEM with unobserved variables and multiple indicators for each variable requires a large sample size. Bentler and Chou (1987) recommend at least five cases for each parameter estimate (including error terms as well as path coefficients). Specifying the complete set of relationships in the conceptual framework with this method would require at least 960 cases. As the sample size is restricted to 166 respondents, composite measures from individual items were created and path analysis was used to specify the final model empirically.

The program chosen for the analyses was LISREL 8.72 (Jöreskog and Sörbom 2005). Although several other programs can be used to conduct the same analyses (like AMOS or

EQS), LISREL is by far the most widely adopted program in marketing and the social and managerial sciences (Steenkamp and van Trijp 1991).

The maximum likelihood (ML) procedure was used to specify parameter estimates based on covariances. ML is a technique that can be used for theory development and testing (Anderson and Gerbing 1988). The ML technique provides estimates based on maximizing the probability that the observed covariances are drawn from a population assumed to be the same as that reflected in the coefficient estimates (Jöreskog and Sörbom 2005). Thus, ML delivers parameter estimates that best explain the observed data.

ML estimation is the default setting in LISREL and the most common method used. Under the assumption of a multivariate normal distribution of the observed variables, ML allows significance testing of the individual parameters and significance testing of the overall model fit. Furthermore, ML allows the estimation of all parameters within a model simultaneously, making it possible to specify several relationships at the same time (Anderson and Gerbing 1988).

After the estimation of a path model with the ML technique, the model should be evaluated to determine to what extent the hypothesized model is consistent with the data. For the evaluation of a path model several goodness-of-fit indices are available (see chapter 5). Although goodness-of-fit tests indicate whether a model should be rejected or not based on the underlying data, these tests do not establish that particular paths within the model are significant. Thus, the inspection of path coefficients and corresponding T-values is necessary after model fit indices have been assessed. The next section describes the analysis of several path models based on the validated measures developed in the previous chapter. First, the consequences of market information processing are evaluated. Then, the antecedents of market information processing are analyzed in three separate path models, one for each category of antecedents. Because of sample size constraints, related to the number of paths, each block of antecedents is first investigated in a separate analysis. Finally, the results of these analyses are assessed in one integrated path model.

6.2 Consequences of market information processing

The conceptual framework and hypotheses for the consequences of market information processing were depicted in chapter 4. The scale development process in chapter 5 resulted in reliable and valid measures for the variables in the conceptual framework, finding two variables more complex than originally theorized. New product performance split into market/financial success and time/cost efficiency. Market information acquisition split into acquiring customer information and acquiring environmental information. Table 6.1 shows the summary statistics and correlations between market information processing variables and new product outcomes.

Table 6.1: Summary statistics, alphas and correlations of market information processing variables and NPD outcomes

	Constructs	Mean:	S.D.:	1	2	3	4	5	6	7	8	9
1	Market/Financial Success	3.21	.91	[.92]								
2	Time/Cost Efficiency	3.15	1.01	**.23****	r=.54							
3	Product Advantage	3.92	.70	**.39****	**.17***	[.80]						
4	Use in Predevelopment	3.23	.86	**.20***	.09	.14	[.74]					
5	Use in Development	3.19	.77	**.21****	.05	**.21****	**.74****	[.71]				
6	Use in Commercialization	3.15	.81	**.16***	-.01	**.26****	**.41****	**.64****	[.71]			
7	Dissemination of Information	2.78	.75	**.17***	.07	**.24****	**.53****	**.52****	**.46****	[.74]		
8	Acquisition of Env. Information	2.99	.78	**.28****	.13	**.19***	**.48****	**.40****	**.30****	**.53****	[.75]	
9	Acquisition of Cust. Information	2.99	.77	**.19***	.13	**.30****	**.39****	**.49****	**.37****	**.51****	**.54****	[.71]

Entries are based on a 5-point scale with '1' = completely disagree and '5' = completely agree.
Bolded correlations are statistically significant. Numbers on the diagonal are Cronbach's alphas.
* $p < .05$
** $p < .01$

Table 6.1 shows that the correlations among the use variables are quite high. To address potential problems due to multicollinearity, each dependent variable (product advantage and both new product performance dimensions) was regressed on the six market information processing variables. The variance inflation factors were all well below 10 (highest = 3.4) indicating that multicollinearity is not a major concern for further analysis (Aiken and West 1991). Figure 6.1 depicts the path model resulting from the scale development process. The relation between the exogenous and endogenous variables in the path model can be represented in LISREL notation as:

$\eta_1 = \beta_{13}\eta_3 + \zeta_1$

$\eta_2 = \beta_{23}\eta_3 + \zeta_2$

$\eta_3 = \beta_{34}\eta_4 + \beta_{35}\eta_5 + \beta_{36}\eta_6 + \zeta_3$

$\eta_4 = \beta_{45}\eta_5 + \beta_{47}\eta_7 + \zeta_4$

$\eta_5 = \beta_{56}\eta_6 + \beta_{57}\eta_7 + \zeta_5$

$\eta_6 = \beta_{67}\eta_7 + \zeta_6$

$\eta_7 = \gamma_{71}\xi_1 + \gamma_{72}\xi_2 + \zeta_7$

where,

η_1 = Market/Financial Success

η_2 = Time/Cost Efficiency

η_3 = Product Advantage

η_4 = Use of Market Information in Commercialization

η_5 = Use of Market Information in Development

η_6 = Use of Market Information in Predevelopment

η_7 = Dissemination of Market Information

ξ_1 = Acquistion of Environmental Information

ξ_2 = Acquistion of Customer Information

$\zeta_{1\text{-}7}$ = Disturbance terms.

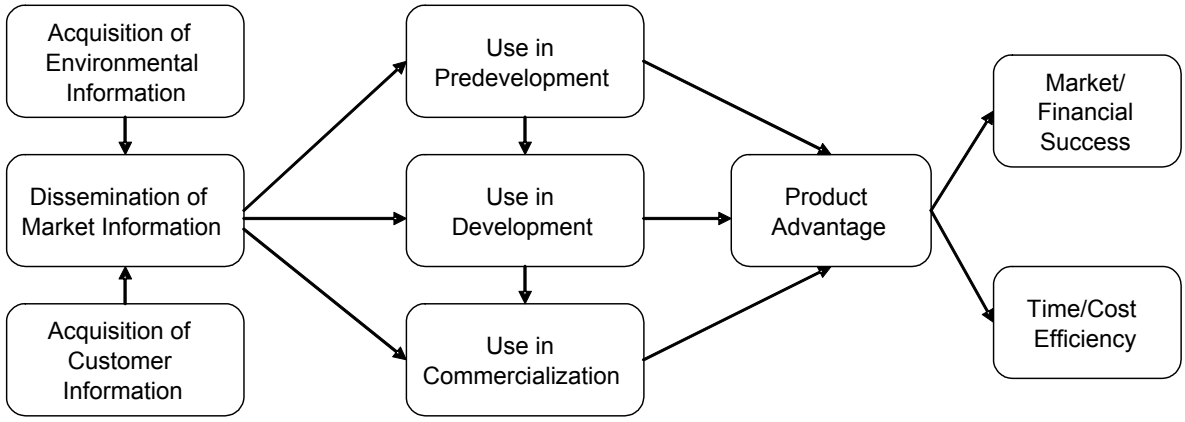


Figure 6.1: Market information processing and NPD outcomes: Post scale development

The β-parameters represent the partial relationships between the endogenous variables (η), while the γ-parameters represent partial relationships between exogenous (ξ) and endogenous (η) variables. The disturbance terms $\zeta_{1\text{-}7}$ represent that part of the dependent variables that is not explained by the independent variables and thus may be interpreted as measurement error (Edwards and Bagozzi 2000). This model was specified using LISREL 8.72. However, the fit statistics for this model indicated poor fit: $\chi^2/df = 2.73$; GFI = .92; AGFI = .85; NFI = .92; NNFI = .91; CFI = .94; IFI = .95; RMSEA = .103.

Poor model fit may be explained by specification errors such as omissions of important linkages among included variables, or inclusion of irrelevant linkages (Diamantopoulos and Siguaw 2000). As bad fit statistics indicate that the specified model does not represent the observed data, some respecification of the structural model was necessary. Respecification decisions should be based on theoretical considerations to reduce the possibility of taking advantage of sampling error to attain goodness of fit (Anderson and Gerbing 1988).

The next step was to explore alternative models among the constructs that provided a better fit, while maintaining the overall logical structure of the theoretical model. First, all hypothesized paths with insignificant path loadings were deleted. Non-significant path

loadings imply that the parameter estimates concerned do not deviate significantly from zero. Therefore, the non-significant paths were deleted and parameter values were fixed at zero (Saris and Stronkhorst 1984).

For the second model, additional paths were created from each of the market information use variables to both performance variables and tested for significance. Market information use in the predevelopment stage was significantly related to market/financial success and was retained for the next model specified. The third model specified included paths from dissemination to each of the other downstream variables (variables to the right of it in Figure 6.1), but none were statistically significant. The fourth model specified included paths from both acquisition variables to all downstream variables. Table 6.2 presents the estimates for the standardized and statistically significant paths for the final model, which is depicted in Figure 6.2.

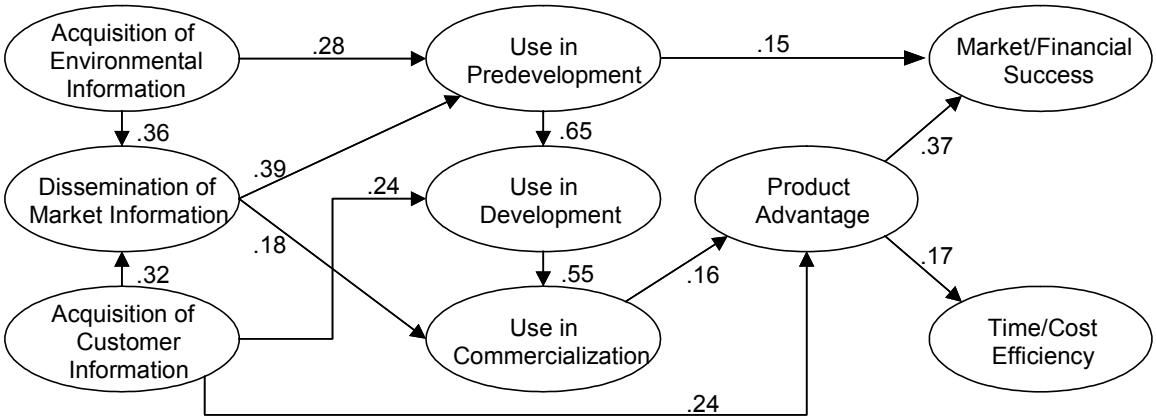


Figure 6.2: Structural equation model of market information processing and NPD outcomes

The fit statistics for this model indicated a good fit: $\chi^2/df = 1.25$; GFI = .96; NFI = .96; NNFI = .99; CFI = .99; IFI = .99; RMSEA = .039. The fit indices suggest that the proposed model was a good explanation of the observed covariances and variances among the study constructs. Furthermore, a chi-square difference test between the hypothesized model and the final model showed that parameter respecification efforts constituted a real improvement (Δchi-square = 35.38; $\Delta df = 1$; $p<.01$).

The results of the analyses show that product advantage is positively associated with each dimension of success: market/financial success (b=0.37) and time/cost efficiency (b=0.17), supporting hypothesis 1. Thus, achieving product advantage is an important activity on which NPD managers may spend their time. The results also show that using market information in the commercialization stage is directly and positively associated with product advantage (b=0.16). Thus, hypothesis 2, concerning the relationship between market information use and product advantage, is partly supported by the data. A potential

explanation of this finding could be that one way managers differentiate their product from competing products in the eyes of the customer is by using market information during commercialization. Hypothesis 3 is supported: increased use in predevelopment is associated with increased use in development (b=0.65), which in turn is associated with increased use in the commercialization phase (b=0.55).

Table 6.2: Standardized estimates and T-values for relationships among market information processing variables and NPD outcomes

Independent variables	Dependent variables	Standardized Estimate	T-Value
Use in Predevelopment	→ Market/Financial Success	.15	2.02
Product Advantage	→ Market/Financial Success	.37	5.14
Product Advantage	→ Time/Cost Efficiency	.17	2.21
Use in Commercialization	→ Product Advantage	.16	2.08
Acquisition of Customer Information	→ Product Advantage	.24	3.08
Acquisition of Environmental Information	→ Use in Predevelopment	.28	3.70
Dissemination of Information	→ Use in Predevelopment	.39	5.18
Acquisition of Customer Information	→ Use in Development	.24	4.41
Use in Predevelopment	→ Use in Development	.65	12.26
Dissemination of Information	→ Use in Commercialization	.18	2.63
Use in Development	→ Use in Commercialization	.55	8.22
Acquisition of Environmental Information	→ Dissemination of Information	.36	4.74
Acquisition of Customer Information	→ Dissemination of Information	.32	4.20

Note: $\chi^2/df = 1.25$; GFI = .96; NFI = .96; NNFI = .99; CFI = .99; IFI = .99; RMSEA = .039.

The hypotheses about the general flow of information from acquisition through dissemination and then use were primarily supported by the data, with a couple of interesting differences. First, acquiring more environmental (b=0.36) and customer (b=0.32) information is associated with increased dissemination across the firm, fully supporting hypothesis 5. Increased dissemination of market information is associated with an increased use of information in the predevelopment (b=0.39) and the commercialization stage of NPD (b=0.18). Thus, the results partly support hypothesis 4. Perhaps, dissemination is not associated with increased market information use in development because the acquired information was not useful during development, or was disseminated ineffectively.

One unexpectedly significant path was associated with the use of market information in the predevelopment stage. The results indicate that using market information in predevelopment is directly associated with market/financial success (b=0.15). Market information is used in predevelopment for such things as segmenting customers, understanding needs, evaluating initial concepts and resolving potential problems with concepts prior to investing in their development. Product advantage is defined in performance and quality terms. This suggests that market-related information other than that which is used to improve the product's physical characteristics contributes to market/financial success.

The three other unexpectedly significant paths were associated with information acquisition. One is that just acquiring environmental information is associated with increased use in predevelopment (b=0.28). The second is that acquiring customer information is associated with increased use in development (b=0.24). One potential explanation of these results could be that the team acquires environmental and customer information directly and thus there is no need to disseminate it through the organization. Those who need it gather it and thus are able to use it directly. These results also suggest that environmental information may be most helpful in the predevelopment stage, when business and market opportunity analyses are being completed. Customer information, on the other hand, may be more useful in development, when details about specific needs and wants are needed to help set specifications and make feature trade-offs. The last unexpected direct effect is between acquiring customer information and product advantage (b=0.24). This can be explained when information on needs is collected directly from customers and then used more intuitively than formally during decision-making.

In summary, path analysis confirmed that there are important differential effects of market information processing variables during high-tech new product development. The results show the power of collecting needs and other diagnostic and evaluative information by the team directly from customers and the marketplace. Higher customer information acquisition both is directly and indirectly associated with information use, and is indirectly associated with both dimensions of success through product advantage. On the other hand, acquiring environmental information is both directly and indirectly associated with information use in the predevelopment stage, and is indirectly related to use in the development and commercialization stage. In addition, using market information in the predevelopment stage is important, since it is related to use in later stages and directly to market/financial success. Finally, product advantage is related to both dimensions of NPD-success: market/financial success and time/cost efficiency.

6.3 Antecedents of market information processing

The conceptual framework and hypotheses for the antecedents of market information processing are depicted in chapter 4 (figure 4.3). Three sets of antecedents are investigated: project urgency characteristics, company structural characteristics and company cultural characteristics. The scale development process reported in chapter 5 resulted in reliable and valid measures for all antecedent variables except for entrepreneurial orientation which had a low internal consistency and was therefore dropped for further analysis. Summary statistics and correlations between antecedent variables, market information processing variables and new product outcomes are reported in table 6.3. Figure 6.3 shows the path model for the antecedents of market information processing resulting from the scale development process.

In the remainder of this section, the relationships between the three sets of antecedents and market information processing are described in three different structural equation models. Because of sample size constraints it is not possible to specify all relationships simultaneously (Bagozzi and Baumgartner 1994). Therefore, each block of antecedents was investigated in a separate analysis.

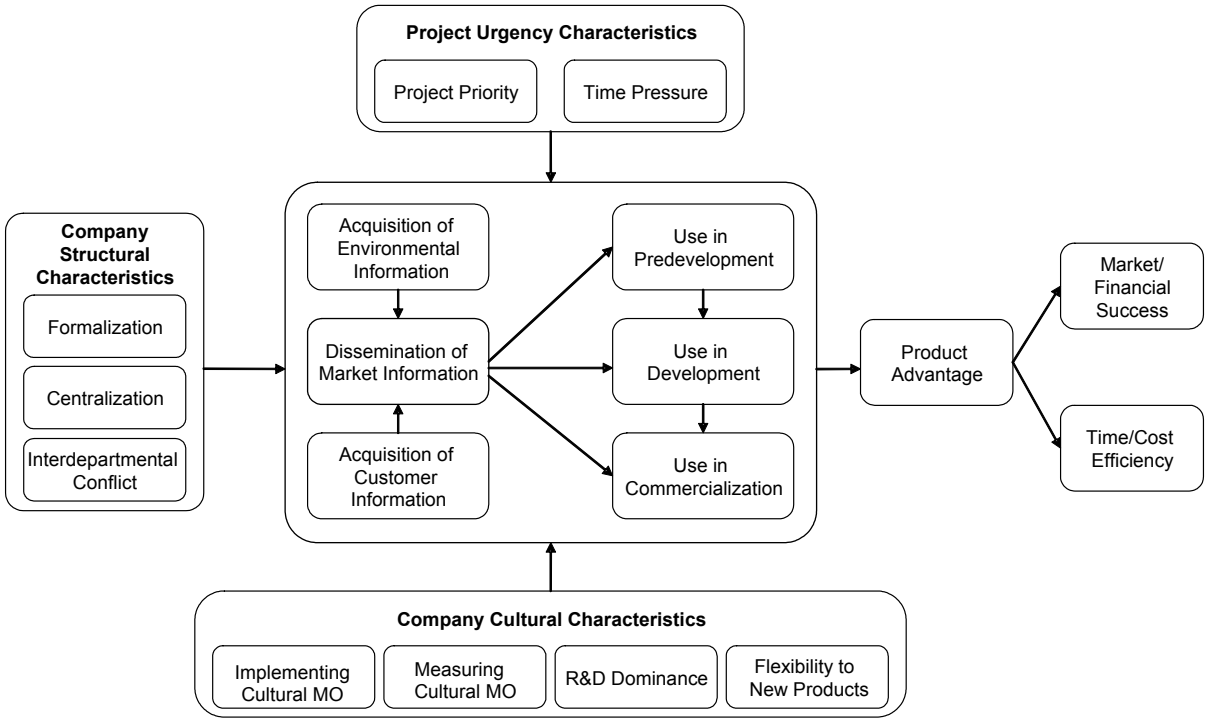


Figure 6.3: Model of antecedents of market information processing and NPD outcomes: Post scale development

Table 6.3: Summary statistics, alphas and correlations of antecedents, market information processing variables and NPD outcomes

	Constructs	Mean:	S.D.:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
New product outcomes																					
1	Market/Financial Success	3.21	.91	[.92]																	
2	Time/Cost Efficiency	3.15	1.01	**.23****	r=.54																
3	Product Advantage	3.92	.70	**.39****	**.17***	[.80]															
Market information variables																					
4	Use in Predevelopment	3.23	.86	**.20***	.09	.14	[.74]														
5	Use in Development	3.19	.77	**.21****	.05	**.21****	**.74****	[.71]													
6	Use in Commercialization	3.15	.81	**.16***	-.01	**.26****	**.41****	**.64****	[.71]												
7	Dissemination of Information	2.78	.75	**.17***	.07	**.24****	**.53****	**.52****	**.46****	[.74]											
8	Acquisition of Env. Information	2.99	.78	**.28****	.13	**.19***	**.48****	**.40****	**.30****	**.53****	[.75]										
9	Acquisition of Cust. Information	2.99	.77	**.19***	.13	**.30****	**.39****	**.49****	**.37****	**.51****	**.54****	[.71]									
Project urgency characteristics																					
10	Project Priority	3.59	.79	**.24****	-.03	**.25****	**.21****	**.20***	**.17***	**.29****	**.24****	**.16***	[.86]								
11	Time Pressure	3.15	.85	-.07	**-.20***	.02	.03	.10	.05	.05	-.01	.05	**.30****	[.81]							
Company structural characteristics																					
12	Formalization	3.68	.70	**.18***	.07	**.20***	.08	**.17***	.14	.06	.03	**.19***	.04	-.05	[.71]						
13	Centralization	2.20	.66	-.08	-.03	**-.27****	**-.17***	-.14	-.14	-.14	**-.16***	**-.17***	-.08	-.04	**-.19****	[.74]					
14	Interdepartmental Conflict	2.78	.73	-.13	**-.23****	-.15	**-.24****	**-.21****	**-.18***	**-.26****	**-.25****	**-.27****	-.09	**.16***	**-.24****	**.23****	[.85]				
Company cultural characteristics																					
15	Implementing Cultural MO	3.63	.75	.13	**.18***	**.16***	**.18***	**.19***	.15	**.21****	**.21****	**.25****	.07	-.08	**.20***	**-.32****	**-.38****	[.71]			
16	Measuring Cultural MO	2.89	.90	**.22****	.07	**.20***	**.27****	**.29****	**.28****	**.48****	**.30****	**.41****	.17	.07	.12	**-.18***	**-.28****	**.37****	[.74]		
17	R&D Dominance	3.51	.88	-.08	-.03	**.18***	.01	.09	.05	.14	.06	.11	.02	-.02	.09	**-.16***	-.07	.11	.03	[.85]	
18	Flexibility to New Products	3.05	.79	**.23****	.12	**.22****	**.16***	**.16***	-.01	**.23****	**.18***	**.17***	.07	-.05	.05	-.07	**-.28****	**.31****	**.23****	**.23****	[.85]

Entries are based on a 5-point scale with '1' = completely disagree and '5' = completely agree.
Bolded correlations are statistically significant. Numbers on the diagonal are Cronbach's alphas.
* $p < .05$
** $p < .01$

6.3.1 Project urgency characteristics

The hypotheses about project urgency characteristics proposed that project priority is positively related to market information processing variables (H6) and that time pressure is negatively related to market information processing variables (H7). The relationships between the project urgency characteristics and market information processing variables are represented in LISREL notation as:

$$\eta_4 = \beta_{45}\eta_5 + \beta_{47}\eta_7 + \gamma_{43}\xi_3 + \gamma_{44}\xi_4 + \zeta_4$$
$$\eta_5 = \beta_{56}\eta_6 + \beta_{57}\eta_7 + \gamma_{53}\xi_3 + \gamma_{54}\xi_4 + \zeta_5$$
$$\eta_6 = \beta_{67}\eta_7 + \gamma_{63}\xi_3 + \gamma_{64}\xi_4 + \zeta_6$$
$$\eta_7 = \beta_{78}\eta_8 + \beta_{79}\eta_9 + \gamma_{73}\xi_3 + \gamma_{74}\xi_4 + \zeta_7$$
$$\eta_8 = \gamma_{83}\xi_3 + \gamma_{84}\xi_4 + \zeta_8$$
$$\eta_9 = \gamma_{93}\xi_3 + \gamma_{94}\xi_4 + \zeta_9$$

where,

η_4 = Use of Market Information in Commercialization
η_5 = Use of Market Information in Development
η_6 = Use of Market Information in Predevelopment
η_7 = Dissemination of Market Information
η_8 = Acquisition of Environmental Information
η_9 = Acquisition of Customer Information

ξ_3 = Project Priority
ξ_4 = Time Pressure
$\zeta_{4\text{-}9}$ = Disturbance terms.

After including all hypothesized relationships, this model was specified using LISREL 8.72. The fit statistics for this model indicated poor fit: $\chi^2/df = 4.21$; GFI = .88; NFI = .84; NNFI = .76; CFI = .87; IFI = .87; RMSEA = .14. Thus, some respecification of the path model was required. The results of the previous analyses for the consequences of market information processing were used to respecify the model. Using the final model of market information processing, product advantage and success as a nested model and linking project urgency characteristics to all market information processing variables resulted in a slightly better, but still

unsatisfactory fit: $\chi^2/df = 2.98$; GFI = .92; NFI = .89; NNFI = .84; CFI = .92; IFI = .92; RMSEA = .11.

Alternative models among the constructs were explored while maintaining the overall logical structure of the theoretical model. First, all hypothesized paths with insignificant path loadings were deleted. As only project priority was significantly related to the acquisition and dissemination of market information, all other paths from the antecedents were removed. For the second model, additional paths were created from each of the project urgency characteristics to product advantage and both success variables. These relationships have theoretical backing, as NPD research has shown for many years that project variables are related to new product outcomes (e.g., Cooper 1999). After including direct relationships of project urgency characteristics to product advantage and success and eliminating the insignificant paths, the fit statistics for this model indicated a much better fit: $\chi^2/df = 2.22$; GFI = .92; NFI = .90; NNFI = .90; CFI = .93; IFI = .94; RMSEA = .087. The fit indices suggest that the proposed model was a reasonable explanation of the observed covariances among the study constructs. Furthermore, a chi-square difference test between the hypothesized model and the final model showed that the modifications had improved the model significantly (Δchi-square = 46.15; Δdf = 6; $p<.01$). Table 6.4 shows the standardized estimates and T-values for the significant relationships in the structural model.

Although prior studies found little empirical support for project priority, partial support was found for hypothesis 6. Project priority is positively related to both acquiring environmental information (b=.24) and acquiring customer information (b=.15). Furthermore, project priority is positively related to disseminating market information (b=.18). If a project is important to a company, more effort will be put into the acquisition of information about customers, competitors and the business environment. After verifying market conditions, the status of the NPD-project may be justified and attention turned toward the dissemination of market information. In general, projects with a higher priority may receive more organizational resources, which may lead to more market information processing.

Contrary to expectations and not supporting hypothesis 7, time pressure is not related at all to the market information processing variables. Perhaps, for companies pursuing high-tech products, the processing of market information is such an important part of the NPD process that it will be done even under conditions of limited time.

Two unexpectedly significant paths were found. The first was associated with project priority and product advantage (b=.20). This finding indicates that project priority also influences product advantage directly besides its indirect effect through market information processing.

Apparently, team members in projects with a high status put a lot of effort in developing products that offer benefits to customers. By doing so, they may be able to show their organizations that the high status of the project was justified. A second significant relationship was found between time pressure and time/cost efficiency (b=-.20). This effect can be easily explained as projects accompanied by high amounts of time pressure are often less cost efficient with large amounts of resources thrown at the project to achieve a shorter time-to-market.

Table 6.4: Standardized estimates and T-values for relationships among project urgency characteristics, market information processing variables and NPD outcomes

Independent variables	Dependent variables	Standardized Estimate	T-Value
Use in Predevelopment	→ Market/Financial Success	.14	1.98
Product Advantage	→ Market/Financial Success	.37	5.14
Product Advantage	→ Time/Cost Efficiency	.17	2.30
Time Pressure	→ Time/Cost Efficiency	-.20	2.63
Use in Commercialization	→ Product Advantage	.14	1.81
Acquisition of Customer Information	→ Product Advantage	.22	2.94
Project Priority	→ Product Advantage	.20	2.65
Acquisition of Environmental Information	→ Use in Predevelopment	.28	4.00
Dissemination of Information	→ Use in Predevelopment	.38	5.32
Acquisition of Customer Information	→ Use in Development	.25	4.65
Use in Predevelopment	→ Use in Development	.67	12.60
Dissemination of Information	→ Use in Commercialization	.17	2.57
Use in Development	→ Use in Commercialization	.54	8.11
Acquisition of Environmental Information	→ Dissemination of Information	.36	4.74
Acquisition of Customer Information	→ Dissemination of Information	.32	4.20
Project Priority	→ Dissemination of Information	.18	2.57
Project Priority	→ Acquisition of Env. Information	.24	3.19
Project Priority	→ Acquisition of Cust. Information	.15	2.00

Note: $\chi^2/df = 2.22$; GFI = .92; NFI = .90; NNFI = .90; CFI = .93; IFI = .94; RMSEA = .087.

6.3.2 Company structural characteristics

The hypotheses about company structural characteristics in chapter 4 posed that formalization is positively related to market information processing variables (H8) and that centralization (H9) and interdepartmental conflict (H10) are negatively related to market information processing variables. The scale development process resulted in reliable and valid measures for formalization, centralization and interdepartmental conflict. The relationships between the company structural characteristics and market information processing variables can be represented in LISREL notation as:

$$\eta_4 = \beta_{45}\eta_5 + \beta_{47}\eta_7 + \gamma_{45}\xi_5 + \gamma_{46}\xi_6 + \gamma_{47}\xi_7 + \zeta_4$$
$$\eta_5 = \beta_{56}\eta_6 + \beta_{57}\eta_7 + \gamma_{55}\xi_5 + \gamma_{56}\xi_6 + \gamma_{57}\xi_7 + \zeta_5$$
$$\eta_6 = \beta_{67}\eta_7 + \gamma_{65}\xi_5 + \gamma_{66}\xi_6 + \gamma_{67}\xi_7 + \zeta_6$$
$$\eta_7 = \beta_{78}\eta_8 + \beta_{79}\eta_9 + \gamma_{75}\xi_5 + \gamma_{76}\xi_6 + \gamma_{77}\xi_7 + \zeta_7$$
$$\eta_8 = \gamma_{85}\xi_5 + \gamma_{86}\xi_6 + \gamma_{87}\xi_7 + \zeta_8$$
$$\eta_9 = \gamma_{95}\xi_5 + \gamma_{96}\xi_6 + \gamma_{97}\xi_7 + \zeta_9$$

where,

η_4 = Use of Market Information in Commercialization
η_5 = Use of Market Information in Development
η_6 = Use of Market Information in Predevelopment
η_7 = Dissemination of Market Information
η_8 = Acquisition of Environmental Information
η_9 = Acquisition of Customer Information

ξ_5 = Formalization
ξ_6 = Centralization
ξ_7 = Interdepartmental Conflict
$\zeta_{4\text{-}9}$ = Disturbance terms.

After including all hypothesized relationships, this model was specified using LISREL 8.72. The fit statistics for this model, however, indicated poor fit: $\chi^2/df = 3.71$; GFI = .89; NFI = .86; NNFI = .77; CFI = .89; IFI = .89; RMSEA = .129. Thus, the path model was modified. First, the results of previous analyses for the consequences of market information processing (section 6.2) were used to respecify the model. Using the final model of market information processing,

product advantage and success as a nested model and linking company structural characteristics to all market information processing variables resulted in a better, but still not acceptable fit: χ^2/df = 2.80; GFI = .92; NFI = .89; NNFI = .84; CFI = .92; IFI = .93; RMSEA = .105. Alternative models among the constructs were explored while maintaining the overall logical structure of the theoretical model. First, all hypothesized paths with insignificant path loadings were deleted. As only formalization and interdepartmental conflict were significantly related to the acquisition of market information, all other paths from the antecedents were removed. Then, additional paths were created from each of the company structural characteristics to product advantage, market/financial success and time/cost efficiency. After including direct relationships for company structural characteristics to product advantage and performance and eliminating the insignificant paths, the fit statistics for this model indicated a more reasonable fit: χ^2/df = 1.90; GFI = .92; NFI = .90; NNFI = .92; CFI = .94; IFI = .94; RMSEA = .074. The fit indices suggest that the proposed model was an acceptable explanation of the observed covariances among the study constructs. Furthermore, a chi-square difference test between the hypothesized model and the final model showed that parameter respecification efforts constituted a real improvement (Δchi-square = 36.99; Δdf = 12; $p<.01$). Table 6.5 shows the standardized estimates and T-values for the significant relationships in the path model.

The results provide partial support for hypothesis 8 about the relationship between formalization and market information processing. Formalization is positively and significantly related to the acquisition of customer information (b=.14). If an organization has well defined guidelines for handling work situations, the acquisition process of customer information is enhanced. No support was found for possible relationships between centralization and market information processing variables and therefore hypothesis 9 is rejected. Apparently, other variables are more important for market information processing in high-tech NPD than the participation of employees in decision making (included in the centralization scale). Interdepartmental conflict is negatively related to the acquisition of both environmental information (b= -.25) and customer information (b= -.23). This finding provides partial support to hypothesis 10 and corroborates findings from earlier market orientation studies (Jaworski and Kohli, 1993; Matsuno et al., 2002).

Two unexpected relationships were found. Although centralization is not related to any of the market information processing variables, one unexpected negative relationship is found with product advantage (b=-.22). Turning this result around, the participation of employees in decision-making during new product development has a direct positive influence on product advantage. If employees do not have to ask their boss' approval for every decision in the design

process, products with increased benefits in the eyes of the customer are the result. A second relationship that was unhypothesized, but that in retrospect is not unexpected is that interdepartmental conflict is negatively related to time/cost efficiency (b= -.21). Organizational actions should be directed towards decreasing conflicts and tension across different departments. If departments cooperate effectively, less time is wasted and products stay within budget.

Table 6.5: Standardized estimates and T-values for relationships among company structural characteristics, market information processing variables and NPD outcomes

Independent variables	Dependent variables	Standardized Estimate	T-Value
Use in Predevelopment	→ Market/Financial Success	.14	1.98
Product Advantage	→ Market/Financial Success	.37	5.11
Product Advantage	→ Time/Cost Efficiency	.14	1.80
Interdepartmental Conflict	→ Time/Cost Efficiency	-.21	2.80
Use in Commercialization	→ Product Advantage	.14	1.91
Acquisition of Customer Information	→ Product Advantage	.21	2.84
Centralization	→ Product Advantage	-.22	2.98
Acquisition of Environmental Information	→ Use in Predevelopment	.28	3.97
Dissemination of Information	→ Use in Predevelopment	.38	5.26
Acquisition of Customer Information	→ Use in Development	.25	4.63
Use in Predevelopment	→ Use in Development	.67	12.55
Dissemination of Information	→ Use in Commercialization	.17	2.56
Use in Development	→ Use in Commercialization	.54	8.10
Acquisition of Environmental Information	→ Dissemination of Information	.38	5.59
Acquisition of Customer Information	→ Dissemination of Information	.33	4.96
Interdepartmental Conflict	→ Acquisition of Env. Information	-.25	3.31
Interdepartmental Conflict	→ Acquisition of Cust. Information	-.23	3.00
Formalization	→ Acquisition of Cust. Information	.14	1.78

Note: $\chi^2/df = 1.90$; GFI = .92; NFI = .90; NNFI = .92; CFI = .94; IFI = .94; RMSEA = .074.

6.3.3 Company cultural characteristics

The hypotheses about company cultural characteristics in chapter 4 posited that cultural market orientation (H11), entrepreneurial orientation (H12) and a firm's willingness to cannibalize (H14) are positively related to market information processing variables and that R&D dominance (H13) is negatively related to market information processing variables.

The scale development process showed that the measure for entrepreneurial orientation did not pass the tests for reliability and construct validity and therefore this variable was removed from the analyses. Thus, hypothesis 12 cannot be explored. Careful inspection of the measurement items remaining after scale purification of the initial construct 'willingness to cannibalize' suggested that they be relabeled as 'flexibility to new products'. Finally, market orientation at the company level split into implementing cultural market orientation and measuring cultural market orientation. In the remainder of the analysis, these different dimensions are treated as distinct variables. The relationships between the company cultural characteristics and market information processing variables can be represented in LISREL notation as:

$$\eta_4 = \beta_{45}\eta_5 + \beta_{47}\eta_7 + \gamma_{48}\xi_8 + \gamma_{49}\xi_9 + \gamma_{410}\xi_{10} + \gamma_{411}\xi_{11} + \zeta_4$$
$$\eta_5 = \beta_{56}\eta_6 + \beta_{57}\eta_7 + \gamma_{58}\xi_8 + \gamma_{59}\xi_9 + \gamma_{510}\xi_{10} + \gamma_{511}\xi_{11} + \zeta_5$$
$$\eta_6 = \beta_{67}\eta_7 + \gamma_{68}\xi_8 + \gamma_{69}\xi_9 + \gamma_{610}\xi_{10} + \gamma_{611}\xi_{11} + \zeta_6$$
$$\eta_7 = \beta_{78}\eta_8 + \beta_{79}\eta_9 + \gamma_{78}\xi_8 + \gamma_{79}\xi_9 + \gamma_{710}\xi_{10} + \gamma_{711}\xi_{11} + \zeta_7$$
$$\eta_8 = \gamma_{88}\xi_8 + \gamma_{89}\xi_9 + \gamma_{810}\xi_{10} + \gamma_{811}\xi_{11} + \zeta_8$$
$$\eta_9 = \gamma_{98}\xi_8 + \gamma_{99}\xi_9 + \gamma_{910}\xi_{10} + \gamma_{911}\xi_{11} + \zeta_9$$

where,

η_4 = Use of Market Information in Commercialization
η_5 = Use of Market Information in Development
η_6 = Use of Market Information in Predevelopment
η_7 = Dissemination of Market Information
η_8 = Acquisition of Environmental Information
η_9 = Acquisition of Customer Information

ξ_8 = Implementing Cultural Market Orientation
ξ_9 = Measuring Cultural Market Orientation
ξ_{10} = R&D Dominance

ξ_{11} = Flexibility to New Products
$\zeta_{4\text{-}9}$ = disturbance terms.

After including all hypothesized relationships, this model was specified using LISREL 8.72. The fit statistics for this model indicated poor fit: χ^2/df = 3.33; GFI = .90; NFI = .88; NNFI = .80; CFI = .91; IFI = .91; RMSEA = .120. The hypothesized model obtained a non-convergent solution, which is a strong indicator of model inadequacy. Several modifications were introduced, in order to obtain a better structure and to increase the fit of the model. First, the results of previous analyses for the consequences of market information processing were used to respecify the model. Second, and similar to previous analyses, all hypothesized paths with insignificant path loadings were deleted. Then, additional paths were created from each of the company cultural characteristics to product advantage, market/financial success and time/cost efficiency. After including direct relationships of company cultural characteristics to product advantage and success and eliminating the insignificant paths, the fit statistics for this model indicated a better fit: χ^2/df = 1.64; GFI = .93; NFI = .92; NNFI = .94; CFI = .96; IFI = .96; RMSEA = .063. The fit indices suggest that the proposed model was a reasonable explanation of the observed covariances among the study constructs. Furthermore, a chi-square difference test between the hypothesized model and the final model showed that the model modifications constituted a real improvement (Δchi-square = 36.29; Δdf = 15; $p<.01$). Table 6.6 shows the standardized estimates and T-values for the significant relationships in the path model.

The results of the analyses show that measuring cultural market orientation is positively and significantly related to the acquisition of environmental information (b=.30), the acquisition of customer information (b=.41), and the dissemination of market information (b=.30), partly supporting hypothesis 11. The measurement of customer satisfaction and customer service at the company level (both items of measuring cultural market orientation) may be a good starting point for gathering and disseminating market information during new product development projects.

R&D dominance is not significantly related to market information processing, rejecting hypothesis 13. A potential explanation is that technical managers meet with customers, like marketing managers do. Although ‘formally’ they are not involved in the marketing function, they do process market information in NPD.

Finally, a company’s flexibility to new products is negatively associated with the use of market information in the commercialization stage (b=-.15), opposite as to what was posited in

hypothesis 14. It seems likely that flexible companies switch their attention to new projects during the final stages of a project, and then use less market information.

Table 6.6: Standardized estimates and T-values for relationships among company cultural characteristics, market information processing variables and NPD outcomes

Independent variables	Dependent variables	Standardized Estimate	T-Value
Use in Predevelopment	→ Market/Financial Success	.12	1.68
Product Advantage	→ Market/Financial Success	.36	5.11
R&D Dominance	→ Market/Financial Success	-.18	2.55
Flexibility to New Products	→ Market/Financial Success	.17	2.39
Product Advantage	→ Time/Cost Efficiency	.14	1.87
Implementing Cultural MO	→ Time/Cost Efficiency	.16	2.08
Use in Commercialization	→ Product Advantage	.18	2.35
Acquisition of Customer Information	→ Product Advantage	.21	2.69
Flexibility to New Products	→ Product Advantage	.19	2.58
Acquisition of Environmental Information	→ Use in Predevelopment	.28	3.86
Dissemination of Information	→ Use in Predevelopment	.38	5.24
Acquisition of Customer Information	→ Use in Development	.24	4.60
Use in Predevelopment	→ Use in Development	.67	12.59
Dissemination of Information	→ Use in Commercialization	.20	3.07
Use in Development	→ Use in Commercialization	.55	8.34
Flexibility to New Products	→ Use in Commercialization	-.15	2.48
Acquisition of Environmental Information	→ Dissemination of Information	.33	5.14
Acquisition of Customer Information	→ Dissemination of Information	.22	3.26
Measuring Cultural MO	→ Dissemination of Information	.30	4.29
Measuring Cultural MO	→ Acquisition of Env. Information	.30	3.94
Measuring Cultural MO	→ Acquisition of Cust. Information	.41	5.62

Note: $\chi^2/df = 1.64$; GFI = .93; NFI = .92; NNFI = .94; CFI = .96; IFI = .96; RMSEA = .063.

Four significant direct relationships between company cultural characteristics and new product outcomes were found. First, the implementation of a cultural market orientation is

positively related to time/cost efficiency (b=.16). Somehow, new product development projects are more efficient when business objectives are driven by customer satisfaction. Second, R&D dominance is negatively related to market/financial success (b= -.18). Putting too much emphasis on R&D may not lead to a financially successful product. In a way, emphasizing R&D during NPD is more cost-intensive, which may harm the ultimate financial performance of a new product. Finally, flexibility to new products is directly and positively related to both product advantage (b=.19) and market/financial success (b=.17). Thus, firms that pursue new technologies, even at the cost of existing projects, reap the benefits when new products hit the market both in terms of new products' advantages over competing products and in financial terms.

6.4 Analysis of the integrated model

Based on the findings from the previous analyses, this chapter concludes with an analysis of the integrated model of relationships between antecedents and consequences of market information processing in high-tech new product development. This final model combines the antecedents that obtained significant relationships with market information processing variables or new product outcomes in the four previous structural models. By doing so, the integrated model shows the relative importance of different sets of antecedents of market information processing. In addition, the model shows the effect of market information processing on new product outcomes while accounting for the other variables included in the overall model.

Although no formal hypotheses were developed for the direct relationships between antecedents of market information processing and new product outcomes, it was thought that the direction and significance of the relationships obtained in the previous models would be maintained. After combining all significant relationships from the previous analyses, the integrated model was specified using LISREL 8.72. This model obtained a good fit to the data: χ^2/df = 1.27; GFI = .93; NFI = .91; NNFI = .96; CFI = .97; IFI = .98; RMSEA = .041. The fit indices suggest that the proposed model is a good explanation of the observed covariances and variances among the study constructs. No formal difference tests between the original hypothesized model and the final model were conducted, as the number of relationships for the hypothesized model would then become too large (9 antecedents x 6 market information processing variables = 54 potential relationships between antecedents and market information processing variables). After deleting the insignificant paths, table 6.7 presents the standardized estimates and T-values for the final model, which is depicted in Figures 6.4a and 6.4b. These two figures refer to the same model and should therefore be considered as one.

The relationships in the integrated model confirm the direction and statistical significance of the variables in the previous models, with a few exceptions. The results show that project priority is positively related to both acquiring environmental information (b=.19) and disseminating market information (b=.14). However, in contrast to the previous model with project urgency characteristics, project priority is not significantly related to acquiring customer information. Apparently other variables, such as the degree of formalization (b=.15) and measuring cultural market orientation at the company level (b=.39), are more important for explaining differences in the acquisition of customer information during new product development.

Interdepartmental conflict is only significantly related to acquiring environmental information (b= -.17) and not related to the acquisition of customer information as was found before. Similar to earlier findings, measuring cultural market orientation at the company level is positively and significantly related to the acquisition of environmental information (b=.22), the acquisition of customer information (b=.39), and the dissemination of market information (b=.29). Also, flexibility to new products (b= -.15) has a negative and significant relationship with the use of market information in the commercialization stage in the integrated model. Thus, the results for the antecedents of market information processing in the integrated model were similar to findings in previous models with two notable exceptions: project priority and interdepartmental conflict were no longer significantly related to acquiring customer information. More importantly, all differential relationships between market information processing variables and new product outcomes remained statistically significant and kept the same sign.

The direct relationships between antecedents of market information processing and new product outcomes are depicted in Figure 6.4b. Project priority (b=.18) is positively and significantly related to product advantage, while time pressure (b=-.17) remains negatively related to NPD time/cost efficiency. Similarly, for the company structural characteristics no differences with previous findings emerged. Centralization (b=-.20) stays negatively and significantly related with product advantage and interdepartmental conflict (b=-.19) remains negatively associated with time/cost efficiency. In addition, the analyses for company cultural characteristics show similar findings, with one exception; implementing cultural market orientation was positively and significantly related to time/cost efficiency in previous analyses, but was no longer significantly related to this performance dimension in the integrated model. R&D dominance (b=-.18) remains negatively related to market/financial success. Finally, flexibility to new products is positively related to both product advantage (b=.17) and

market/financial success (b=.17) in the integrated model, as was the case in the model for company cultural characteristics.

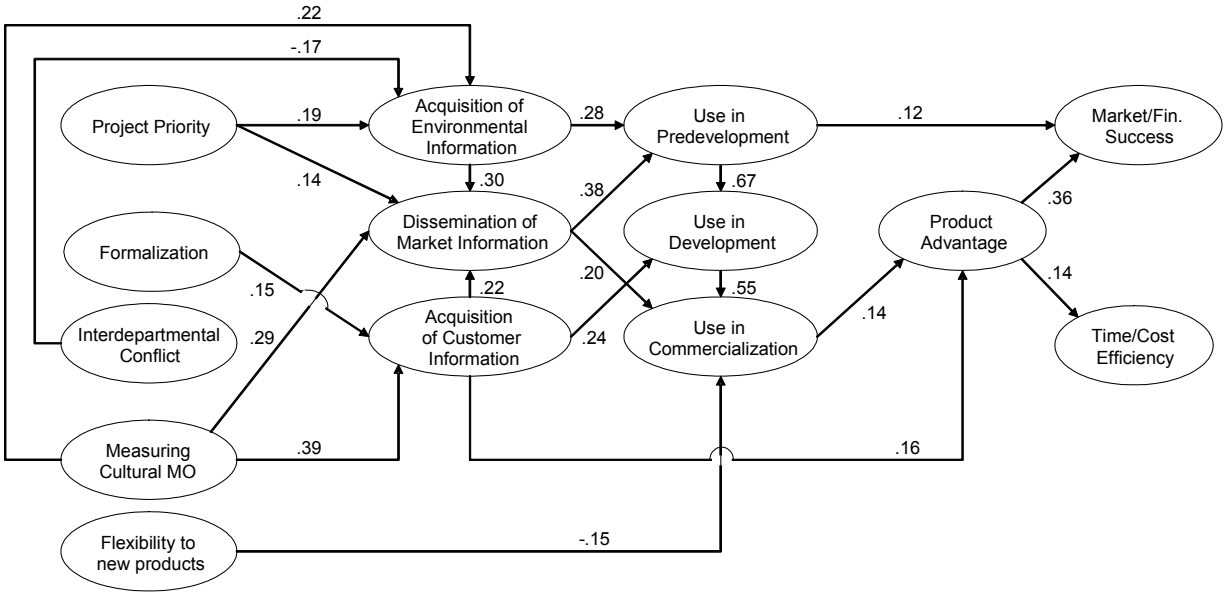


Figure 6.4a: Integrated model of antecedents of market information processing variables and NPD outcomes

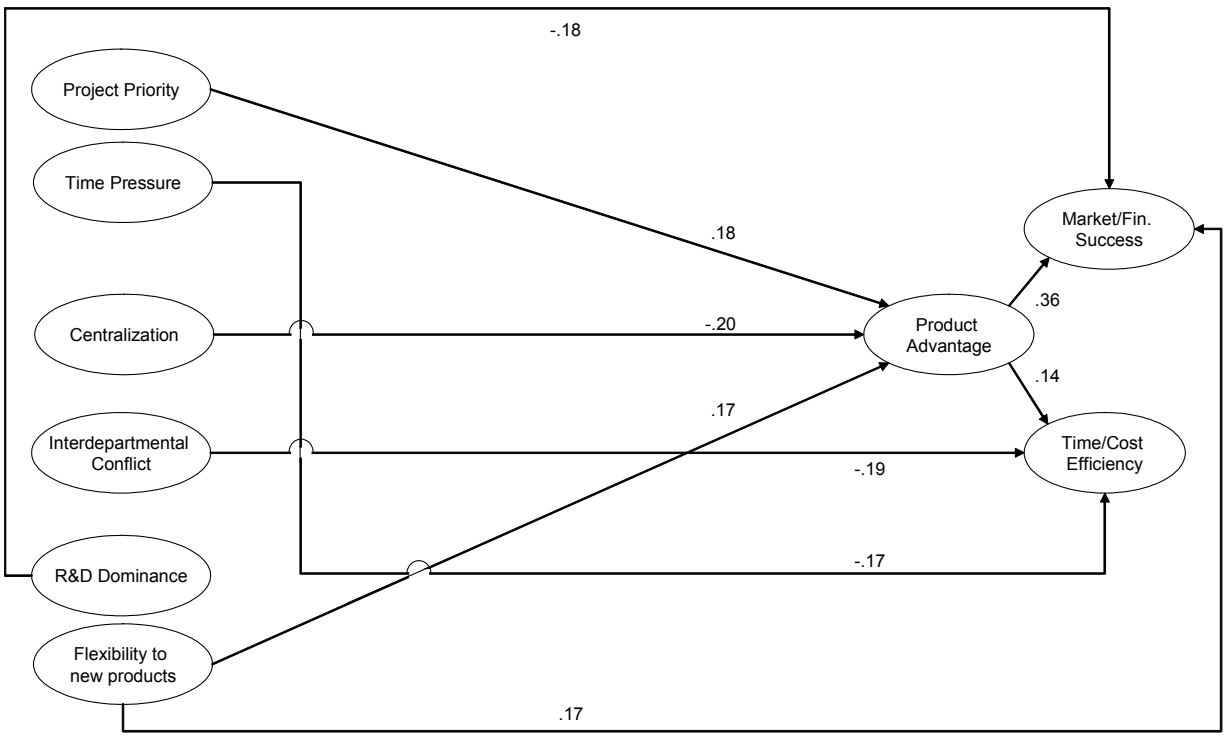


Figure 6.4b: Integrated model of antecedents of market information processing variables and NPD outcomes

Table 6.7: Standardized estimates and T-values for relationships among project urgency characteristics, company structural characteristics, company cultural characteristics, market information processing variables and NPD outcomes

Independent variables	Dependent variables	Standardized Estimate	T-Value
Use in Predevelopment	→ Market/Financial Success	.12	1.66
Product Advantage	→ Market/Financial Success	.36	5.00
R&D Dominance	→ Market/Financial Success	-.18	2.51
Flexibility to New Products	→ Market/Financial Success	.17	2.36
Product Advantage	→ Time/Cost Efficiency	.14	1.88
Time Pressure	→ Time/Cost Efficiency	-.17	2.21
Interdepartmental Conflict	→ Time/Cost Efficiency	-.19	2.39
Use in Commercialization	→ Product Advantage	.14	1.85
Acquisition of Customer Information	→ Product Advantage	.16	2.19
Project Priority	→ Product Advantage	.18	2.46
Centralization	→ Product Advantage	-.20	2.80
Flexibility to New Products	→ Product Advantage	.17	2.38
Acquisition of Environmental Information	→ Use in Predevelopment	.28	3.81
Dissemination of Information	→ Use in Predevelopment	.38	5.18
Acquisition of Customer Information	→ Use in Development	.24	4.54
Use in Predevelopment	→ Use in Development	.67	12.43
Dissemination of Information	→ Use in Commercialization	.20	3.02
Use in Development	→ Use in Commercialization	.55	8.23
Flexibility to New Products	→ Use in Commercialization	-.15	2.44
Acquisition of Environmental Information	→ Dissemination of Information	.30	4.59
Acquisition of Customer Information	→ Dissemination of Information	.22	3.28
Project Priority	→ Dissemination of Information	.14	2.23
Measuring Cultural MO	→ Dissemination of Information	.29	4.06
Project Priority	→ Acquisition of Env. Information	.19	2.53
Interdepartmental Conflict	→ Acquisition of Env. Information	-.17	2.26
Measuring Cultural MO	→ Acquisition of Env. Information	.22	2.78
Formalization	→ Acquisition of Cust. Information	.15	2.03
Measuring Cultural MO	→ Acquisition of Cust. Information	.39	5.34

Note: $\chi^2/df = 1.27$; GFI = .93; NFI = .91; NNFI = .96; CFI = .97; IFI = .98; RMSEA = .041.

6.5 Summary and conclusions

This chapter examined antecedents and consequences of market information processing with path analysis and ML estimation techniques. The first path model examined the extent to which market information processing is associated with new product outcomes during high-tech new product development. It showed that different market information processing variables are all positively and differentially related to product advantage and new product performance. Acquiring customer information is directly related to the dissemination of market information, use of market information in the development stage, and to product advantage. Acquiring environmental information is directly related to the dissemination of market information and use of market information in the predevelopment stage. The dissemination of market information is directly related to the use of market information during predevelopment and commercialization. The use of market information in the predevelopment stage is directly related to using market information in development and to market/financial success. Finally, using market information during development is directly related to the use of market information in commercialization, which in turn is related to creating product advantage. Product advantage remains a dominant driver of new product performance, as it positively influences both market/financial success and time/cost efficiency.

Then, three sets of antecedents of market information processing (project urgency, company structural and company cultural characteristics) were analyzed in three separate path models. After several model modifications, the overall fit for each model was adequate and the majority of the hypotheses were confirmed by the results. Finally, the results for the antecedents and consequences of market information processing were assessed in one integrated model. The general conclusion concerning the antecedents of market information processing is that market information processing in new product development is mainly influenced by project priority and measuring cultural market orientation at the company level. The degree of formalization also has a positive influence on market information processing. Both interdepartmental conflict and flexibility to new products are negatively related to market information processing in NPD. More importantly, the results of the integrated model confirmed the important role of market information processing in high-tech new product development. Even when the three sets of antecedents were accounted for, the positive relationships between market information processing and NPD outcomes remained.

Chapter 7 – Discussion of the results

The objective of this doctoral research project was to contribute to the marketing and NPD literatures by focusing on the antecedents and consequences of market information processing in high-tech NPD. Based on a review of the extant literature and interviews with practitioners a conceptual framework was developed linking project and company characteristics through market information processing in three generic stages of NPD to product advantage and new product performance. Chapter 6 presented the results of specifying the conceptual framework with data on 166 NPD projects.

To discuss the results with respondents, a feedback seminar was organized at the Faculty of Industrial Design Engineering at the Delft University of Technology. All respondents to the mail survey received an invitation to this seminar. The feedback seminar included a presentation of the results and a discussion that offered some alternative explanations for the findings. The current chapter discusses the results and draws conclusions with respect to the diverse relationships between market information processing and new product outcomes, project urgency characteristics, company structural characteristics, and company cultural characteristics.

The current chapter is structured as follows. Section 7.1 summarizes the main findings. Section 7.2 discusses the findings and management implications for the relationship between product advantage and new product performance. Section 7.3 presents the results and management implications for the relationships between market information processing variables and new product outcomes. Section 7.4 draws conclusions for the antecedents of market information processing (project urgency characteristics, company structural characteristics and company cultural characteristics). Section 7.5 describes the limitations of this research and provides suggestions for further research. Finally, section 7.6 concludes the chapter with a discussion of the main contributions.

7.1 Summary of main findings

The primary purpose of this research project was to develop a better understanding of the role that market intelligence plays during the development process of new high-tech products. The introduction in chapter 1 pointed to a controversy about the importance of market information processing in high-tech NPD. On the one hand, the development of new high-tech products requires a high level of market information processing (Daft and Huber 1987). On the other hand, market information processing may be detrimental to successful NPD (Bennett and Cooper 1981, Christensen and Bower 1996, Hamel and Prahalad 1994, Martin 1995, Tauber 1974). By considering the consequences of market information

processing for new high-tech products, this doctoral research aimed to help unravel parts of this controversy.

The results in chapter 6 demonstrated that the market information processing variables are positively related to new product outcomes, not supporting previous studies that have downplayed the role of market information in NPD performance. Some aspects of market information processing (acquisition of customer information and information use in commercialization) were directly related to product advantage, while other aspects of market information processing (acquisition of environmental information, dissemination of market information, use in predevelopment, and use in development) were related only indirectly to this desired outcome. The results also indicated a temporal structure for the flow of information from acquisition through dissemination into use. In addition, the present study found that market information use in the predevelopment stage of NPD was related to use in the development stage, which in itself was related to use in the commercialization stage. Finally, product advantage was found to partially mediate the relationship between market information processing and new product performance.

A secondary purpose of this doctoral research project was to explore the antecedents of market information processing in high-tech NPD. An examination of the literature and insights from interviews with practitioners identified three sets of antecedents of market information processing: project urgency characteristics (project priority and time pressure), company structural characteristics (formalization, centralization and interdepartmental conflict), and company cultural characteristics (market orientation, entrepreneurial orientation, R&D dominance and flexibility to new products). The first set of antecedents was derived from the interviews with developers of new high-tech products. The second set of antecedents was based on the market orientation and innovation literatures. The third set of antecedents contained three variables that were derived from the literature and one variable (R&D dominance) that was derived from the interviews with practitioners.

The results for the antecedent variables in chapter 6 showed that project priority, formalization and measuring market orientation at the company level are positively associated with market information processing during high-tech NPD. Thus, each set of antecedents uncovered at least one positive and significant relationship with market information processing. However, interdepartmental conflict and flexibility to new products were negatively related to market information processing. In addition to these relationships, this research also found several direct links between the antecedents of market information processing and new product outcomes. The next sections discuss the main results and provide managerial implications for the antecedents and consequences of market information processing in high-tech NPD.

7.2 Product advantage and new product performance

First, as many previous authors have demonstrated empirically (e.g., Cooper and Kleinschmidt 1987, Griffin and Page 1993, 1996, Hart 1993, Hultink and Robben 1995, Langerak et al. 2004), the results in chapter 5 confirmed that performance at the project level is a multidimensional construct.

Sixteen indicators assessed the performance of a single product development project (Griffin and Page 1993, 1996). Ratings on these indicators were subjected to EFA and CFA, resulting in a two-dimensional solution. The first dimension of NPD performance (market/financial success) was a combination of market acceptance and financial performance indicators, whereas the second dimension (time/cost efficiency) referred to indicators of speed to market and adherence to the development budget, internal project-related measures of success. As the indicators of new product performance were combined with indicators of product advantage in one CFA model, a substantial number of indicators (10 items) for new product performance had to be dropped. Most of these indicators did not load cleanly on the two performance dimensions because they had an overlap with product advantage. Together, these findings show that NPD performance of high-tech products consists of two different dimensions that can be measured with a relatively small amount of items.

Consistent with the extant literature on success factors in NPD (e.g., Cooper 1985, Henard and Szymanski 2001, Montoya-Weiss and Calantone 1994, Song and Parry 1997) this research project also found that product advantage was positively related to both performance dimensions: market/financial success and time/cost efficiency. The strong positive relationship with market/financial performance can be explained as new product adoption is positively influenced by unique customer benefits and a superior value of the new product over competing products (Rogers 2003). When a new product offers more benefits than competing products, customers are more likely to buy this product.

The finding that product advantage is positively related to time/cost efficiency may appear less obvious. Product advantage is often determined in the early stages of NPD, before the business case is presented and product specifications are set. Perhaps, if new product goals are clear from the beginning it is less likely that the NPD project will be interrupted or run out of budget. When a project has the right specifications, it may be easier to control the project with regard to time and money. On the other hand, products that score low on product advantage may have a longer development process because of reformulating product specifications, for example, because the product doesn't fit in the market, or because a competitor is developing a similar product (Hultink and Hart 1998). An alternative explanation was mentioned during the feedback seminar: companies that develop high-quality products are often in a higher price-range with higher margins on all of their products.

This means that these companies likely have larger budgets, which makes it easier to stay within the budget.

Together, the results of this research confirmed the leading role of product advantage in creating successful new products. Therefore, NPD managers need to make sure that their NPD projects contain steps to encourage the creation of product advantage. In addition, they must be able to explain the potential benefits of their products for customers. Listing these potential benefits in the early phases of an NPD project may be a good way to start with.

7.3 Market information processing

Based on the behavioral market orientation literature, market information processing was defined as the acquisition, dissemination and use of market information. Several authors have suggested that there is a potential causal ordering or temporal structure among these three components of market information processing (e.g., Daft and Weick 1984, Kohli et al. 1993). The acquisition of information must occur before it can be disseminated (Souder and Moenaert 1992), and disseminated to the appropriate people (those who need it), before it can be used (Zahay and Griffin 2004, Sinkula et al. 1997). The results of this research indicated that there is a temporal order, as the acquisition of market information was related to disseminating information, which in turn was related to the use of market information. Thus, a primary focus of NPD project leaders must be to ensure that team members spend the necessary time upfront to acquire information and that they are free to do so. Emphasizing the importance of gathering market information from the start is necessary as it creates the right attitude for further market information processing.

7.3.1 Use of market information

Several findings for the use of market information are explained in more detail. First, the positive relationship between using market information in predevelopment and market/financial success was not formally hypothesized. However, previous studies have found similar results. For example, Montoya-Weiss and Calantone (1994) showed that solid homework in the predevelopment stage increases new product success rates significantly. Furthermore, Cooper and Kleinschmidt (1995) found that up-front homework is correlated positively and significantly with the profitability of new product efforts. One manager at the feedback seminar explained that using market information in the predevelopment stage can be helpful in choosing the right project. This again means that it is crucial to start the project off with the right attitude toward market information processing.

Second, the finding that only using market information in the commercialization stage was positively related to product advantage raised several questions during the feedback seminar. For example, one manager doubted whether product advantage can still be created

at this late stage of the NPD process. Indeed, it may be difficult to change design parameters in the commercialization stage when the new product is ready for launch. On the other hand, new high-tech products often contain many benefits that may be difficult to observe from the outside. Thus, perhaps it is not so much the way in which these benefits are created, but the way in which these benefits are explained to customers that creates product advantage in the commercialization stage.

Market information during commercialization can be used to improve communication platforms. For example, one manager at the feedback seminar explained how his company used customer reactions in their new product's catalogue to emphasize product advantage. Furthermore, market information is helpful in the commercialization stage to identify which of the many new product attributes customers prefer. Based on this information, sales people may be able to tell the stories to customers they want to hear, for example, by stressing specific customer benefits.

To summarize, using market information in the commercialization stage is important for creating product superiority in the eyes of the customer. Therefore, NPD managers should encourage NPD team members to use market information during commercialization and to learn which new product benefits must be communicated to customers.

7.3.2 Dissemination of market information

One notable finding for the dissemination of market information is that information dissemination was not directly associated with information use in the development stage. A potential explanation for this result is that, in these projects, information was gathered by the core team early in the project, and was disseminated to the larger team only in the early and late stages of the project, and not during development. For example, information sharing may have taken place broadly at the start of the project, and then the organization assumed that the development team now had the information it needed, so no efforts were taken specifically to disseminate additional information in development. Then during commercialization different information about customers and the environment had to be disseminated to the more complete team again (including, perhaps, additional marketing and sales personnel not on the core team) in order to create the marketing communications that would effectively launch the new product.

An alternative explanation for this finding is that the information was disseminated ineffectively during the development stage, and therefore it has not been used. For example, Maltz and Kohli (1996) found that both the frequency and formality of information dissemination had an effect on the perception of market information and subsequently the use of it. As project members have different information needs during development (cf.

Zahay et al. 2004), they also may have different needs for how the information is disseminated.

This finding implies that market information must be disseminated in the right way to increase the chance that market information will be used. NPD managers should, therefore, monitor that the dissemination of market information is customized to the wishes of project members and that a sufficient amount of market information is successfully disseminated to the NPD project team.

7.3.3 Acquisition of market information

The results of this research project indicated that acquiring different types of market information has different effects on market information processing variables and new product outcomes. Apparently, turning customer information into innovation is a different process than turning environmental information into innovation. A remarkable difference between these two information flows is that environmental information acquisition was directly related to information use in predevelopment, whereas acquiring customer information went directly to information use in development.

One potential explanation of these results could be that the acquisition of environmental information may be most helpful in the predevelopment stage when business and market opportunity analyses are being completed. Customer information, on the other hand, may be more useful in development, when details about specific needs and wants are needed to help set specifications and make feature trade-offs. Both of these results are in line with previous findings from Zahay et al. (2004) about the differential use of different types of information across the development process.

Differences between these two types of market information were also observed in the case study of the car navigation project in chapter 3. Environmental information was more important in the early stages of development because it was needed for crucial decisions on the business development (e.g., by providing information on the availability of digitized roadmaps). Information about customers was used more often after the predevelopment stage to adjust product specifications based on user and consumer research.

One implication of this finding is that NPD managers must be aware that different types of information are needed at different stages. The team also should be encouraged to think about the information they gather more broadly than just that about customer needs.

7.3.4 Using market information without dissemination

Respecification of the conceptual framework uncovered direct relationships between the acquisition of customer and environmental information and the use of market information.

The results showed that market information can also be used when information has not been disseminated.

One potential explanation for these direct links could be that the NPD project team acquires environmental and customer information directly and thus there is no need to disseminate it through the organization. Those who need it gather it, and thus, are able to use it directly in the stages where it will be most beneficial. For example, practitioners at the feedback seminar referred to 'customer visits' as an effective method to gather customer information for the cross-functional project team (McQuarrie 1998). When the project team acquires customer information by visiting customers on-site, there is no need to disseminate this information, it just gets used in the project.

An alternative explanation is that the market information collected was entered into an information system, and therefore, no explicit dissemination was necessary. For example, at General Electric comments from customer calls are systematically recorded by service representatives and later analyzed by product developers. By listening to these customer calls product developers get a feeling for the customer's voice and mood (Davenport, Harris and Kohli 2000).

A second direct relationship was found for acquiring customer information, as it was also directly related to product advantage. One potential explanation for this result could be that customer information, in terms of market research and interacting with potential customers, may be used more intuitively than formally during decision-making. For example, at the feedback seminar one manager explained that in his company customer information was sometimes used informally, because it was acquired in an earlier stage when designers spoke with customers. In these informal discussions a decision was already taken about where the project was going, but this was not a formalized decision in the NPD process. Thus, team members may integrate their intuitive understanding of needs and wants into the new product unconsciously.

One implication of these findings is that NPD managers may want to encourage their project teams to gather market information themselves, rather than depend upon outside firms for acquiring it. Therefore, project members may need to reserve more time for talking to customers, speaking with competitors, and analyzing the environment to gather information directly.

7.4 Antecedents of market information processing

Based on the findings in chapter 6 it can be concluded that some project and company characteristics are more beneficial than others for successfully processing market information. Notable results for the three sets of antecedents of market information

processing (project urgency characteristics, company structural characteristics and company cultural characteristics) are discussed below.

7.4.1 Project urgency characteristics

The results showed that project priority was more beneficial to market information processing than time pressure. Project priority was defined as the importance and the status of a NPD project, compared to other projects also in development. If a project is highly important to a company this goes together with increased acquisition and dissemination of market information.

Based on these findings management may be advised to increase a project's priority to stimulate market information processing. However, good feedback from the market on a new product idea could also increase a project's priority. Therefore, the direction of the relationship between project priority and market information processing may be reversed. Since this research project used a cross-sectional survey design, this direction of causality can not be determined (as will be discussed further in section 7.5.2).

Despite the ambiguity about the direction of causality, knowledge about a positive relationship between project priority and market information processing could be beneficial to practitioners. For example, when a project manager has a strong conviction that a new product idea will become a successful product, but the project is not yet on the priority lists of the company, the first thing to do is to increase the project's priority. After convincing top management, the project may receive resources for a first market study. If the results of this market study confirm prior beliefs, project priority may in turn increase.

Time pressure

Although the interviews with practitioners revealed that time pressure may decrease market information processing, the results of chapter 6 did not confirm this. Time pressure was not significantly related to any of the market information processing variables. According to one manager at the feedback seminar, this non-significant relationship between time pressure and market information processing can be explained by an alternative version of the frequently used '80-20' rule that 80 percent of sales is generated by 20 percent of the clients. In the case of market information acquisition, this principle translates to the fact that 80 percent of the market information is often generated in 20 percent of time. Thus, the most valuable market information may be acquired within a short period of time. Therefore, time pressure becomes less relevant for market information processing, even in high-tech NPD.

Another manager explained that market information processing is a manner of professionalism or organizational culture and has nothing to do with time pressure. Thus, if an organization has a culture that stimulates market information processing, it doesn't matter

how fast a project must be completed, the NPD project team will always gather market information. An implication of this finding is that market information processing should be such an important part of the NPD process that it will be done even under conditions of limited time.

7.4.2 Company structural characteristics

The results for the company structural characteristics showed that formalization was most beneficial and interdepartmental conflict was least beneficial to market information processing in high-tech NPD. Centralization was not related to any of the market information processing variables.

Formalization

Formalization was positively related to the acquisition of customer information. It is remarkable however, that formalization was not related to the acquisition of environmental information. Perhaps, this finding can be explained as the acquisition of customer information is often formalized in management guidelines. The importance of integrating customer information in NPD has been stressed for many years (Griffin and Hauser 1993). Furthermore, the measurement of customer satisfaction has been described in ISO-9000 quality norms as an important element of an organization's quality management system. Apparently, companies have implemented these lessons and formalized the acquisition of customer organization in their organizations. Clearly, not so many organizations have formalized the acquisition of environmental information in their organizational structures. Therefore, it may be more likely to find a significant and positive relationship between formalization and the acquisition of customer information but no significant relationship between formalization and the acquisition of environmental information.

The finding that formalization is positively related to customer information acquisition implies hat companies need some structure to increase the acquisition of customer information during high-tech NPD. Companies may also need to verify whether the acquisition of environmental information has been already implemented in organizational rules.

Centralization

Centralization of organizational structure was not related to market information processing variables. Despite these non-significant relationships, centralization was negatively related to achieving product advantage. If employees are not allowed to make their own decisions on the job, they may become less involved and less motivated project members, which may result in a decreased focus on creating product advantage.

This result implies that the participation of all employees in decision-making is important for developing product benefits and therefore, high-tech companies should decentralize decision-making authority to lower levels in the organization.

Interdepartmental conflict

Finally, the results of the structural antecedents showed that interdepartmental conflict was negatively associated with the acquisition of customer and environmental information. One implication of this finding is that managers may bring the goals of different departments in closer harmony with each other to increase the acquisition of market information. When departments only strive for their own goals they may lose sight of the organizational goals. Therefore, companies may provide departments with a common goal.

A second implication is that organizations may decrease too much tension among employees from different departments. Therefore, firms may stimulate open communication and bring different departments closer to each other. Griffin and Hauser (1996) described six general approaches to achieve functional integration that may be used for reducing interdepartmental conflict: (1) relocation and physical facilities design, (2) personnel movement, (3) informal social systems and culture, (4) organizational structure, (5) incentives and rewards, and (6) formal integrative management processes. Together these approaches could reduce interdepartmental conflict and highlight the importance of cooperation and informality between departments.

7.4.3 Company cultural characteristics

The results for the company cultural characteristics showed that measuring a cultural market orientation at the company was most beneficial to market information processing in high-tech NPD. On the other hand, flexibility to new products was detrimental to market information processing.

Cultural market orientation

A cultural market orientation, as measured in this research project, consisted of two distinct variables: implementing cultural market orientation and measuring cultural market orientation. Measuring cultural market orientation refers to such things as measuring customer satisfaction and polling end users systematically. Implementing cultural market orientation means that business objectives and strategy are driven by customer satisfaction and customer needs. The results for a cultural market orientation showed that only the measurement aspect of a cultural market orientation was positively related to market information processing variables at the NPD project level.

These results confirm that organizations with a market oriented culture are indeed more likely to increase market information processing in high-tech NPD. Furthermore, it is important to measure customer satisfaction at the company level to increase market information processing at the NPD project level.

Entrepreneurial orientation

The variable entrepreneurial orientation and its three dimensions (innovativeness, risk taking and proactiveness) did not result in a reliable measure. This indicates that managers in the sampled companies do not agree that these dimensions of entrepreneurial orientation are measuring the same construct. The original scale for entrepreneurial orientation was validated on a sample of U.S. manufacturing companies (Matsuno et al. 2002). Perhaps, the measurement of entrepreneurial orientation in the Netherlands is more problematic because companies in the Netherlands may not be so entrepreneurial. Indeed, reports on entrepreneurship in the Netherlands confirm that companies in the Netherlands score low on entrepreneurship compared to other countries, such as the U.S. (Statistics Netherlands 2007). Particularly, the attitude of individuals toward entrepreneurship in the Netherlands is lower than in many other countries. This may be one reason why it is more difficult to measure different aspects of an entrepreneurial orientation in the Netherlands. Future research on entrepreneurial orientations could benefit from an adapted measure for entrepreneurial orientation that is more customized to a country's specific situation.

R&D dominance

The finding that R&D dominance was not related to market information processing did not support initial findings from the exploratory interviews with practitioners. This indicates that R&D dominance may be problematic for market information processing in some companies, but not for the majority of sampled firms in the mail survey. Perhaps, the interviewees who mentioned several aspects of R&D dominance were more displeased with their companies' engineering driven cultures than others.

The statistically insignificant relationship between R&D dominance and market information processing may be explained as many employees with a technical background meet with customers just like employees with a non-technical background do. For example, one manager at the feedback seminar indicated that their R&D personnel spend 25% of their time outside with customers. As a result, R&D employees within this company said that 'one hour in the market saves you two weeks in the laboratory' as an alternative to the old saying that 'one hour in the library saves you one week in the laboratory.'

Although R&D dominance may be less important for market information processing in high-tech NPD, too much R&D dominance may be undesirable as it results in less successful

products. This finding implies that R&D dominance is an undesirable company cultural characteristic that should be reduced to develop financially successful products. If companies want to reduce R&D dominance, they may build a more balanced composition of their workforce with a mix of both technical and non-technical employees. In addition to technical skills, managers may want to stress the importance of non-technical skills within their organizations. Together, these actions could help firms reduce the potential negative effects of too much R&D dominance.

Flexibility to new products

The finding that flexibility to new products was negatively related to the use of market information in the commercialization stage suggests that firms can become too flexible. If firms adopt new technologies too easily, they run the risk that the final stages of existing projects are not completed the way they should. Perhaps, these companies find out that their existing projects will soon become outdated and therefore they switch attention to new projects too early. This is undesirable, as market information use in the commercialization stage is important for improving new product outcomes. However, flexibility to new products was also directly and positively related to product advantage and market/financial success. Moreover, these direct effects on new product outcomes are stronger than the indirect effects through using market information in the commercialization stage. This finding suggests that companies may benefit from being more flexible towards new products, despite the negative association with market information use.

7.5 Limitations and further research

Several limitations should be considered when interpreting the results of this research project. The current section discusses to what extent the results are an artefact of the research method and presents the limitations of this research project around three main themes: informant issues, methodological issues, and measurement issues.

7.5.1 Informant issues

This research used the key informant method which has several limitations. For example, using single informants increases the risk of common method bias. Common method bias refers to the variance that is attributable to the measurement method rather than to the constructs the measures represent (Podsakoff, MacKenzie, Lee and Podsakoff 2003). The single-informant approach can be biased by artificially high correlations between different constructs. Due to several response biases (such as social desirability, or yea- and nay-saying) informants may answer similarly to multiple items of different constructs even when there is no true correlation between these constructs. Thus, relationships between

independent and dependent variables may be inflated as a result of common method bias. Exploratory factor analysis with Harman's one-factor method indicated that common method bias was not a major problem in this research project (Podsakoff and Organ 1986). To further reduce the risk of common method bias, future research should gather data on independent and dependent variables from different respondents.

Another limitation concerns the use of retrospective data. Although respondents were asked to select new products that were introduced in the last three years, their development likely started several years before. Therefore, informants may have had some difficulties providing accurate answers to some questions in the survey. Bias from this source was reduced by surveying respondents who were responsible for and had been involved in the development project of a specific NPD project. Future research may employ a more experimental or longitudinal research design to assess market information processing activities during NPD projects.

Since development may have taken several years, one may question whether the people involved in predevelopment were the same as the ones in development and commercialization. Especially in large companies, the composition of NPD-teams may change during NPD. In this research project, this problem was reduced by selecting key-informants that were knowledgeable of the whole NPD-project. Future research may identify different informants for different stages in the NPD process.

This research project identified respondents who were most knowledgeable about a specific NPD project. As a consequence (since NPD is a multi-functional process), respondents came from different functional departments. The largest number of respondents (37.9%) came from the R&D function. This could have biased the results as R&D personnel may provide different responses to questions about market information processing than marketing personnel. This problem is also known as respondent bias (van Bruggen, Lilien and Kacker 2002). Ernst and Teichert (1998) argued that respondent bias may occur when respondents from R&D and marketing are asked to assess the specific input of each function into the NPD process. For example, in a study on interdepartmental integration in the electronics industry, Kahn (1996) found different relationships between interdepartmental integration and new product performance based on the answers from marketing, manufacturing or R&D personnel.

Although mean difference tests in the current research project did not show any differences between the answers of R&D and marketing personnel, there still may be differences in the relationships that were found for R&D and for marketing. For example, one may expect that respondents from a marketing department think that market information is more important than respondents from an R&D department and therefore relationships may be different for marketing respondents. Unfortunately, the use of key-informants and the

sample size of this study did not allow for these tests to be conducted. Future research may select respondents from only one functional department, or obtain data from multiple respondents in each firm to allow the comparison of relationships between respondents from different functions.

7.5.2 Methodological issues

Although the conceptual framework proposed directionality in the relationships, this could not be tested with the applied research methodology. This research project used a cross-sectional survey to gather data on a large number of NPD-projects and used path analysis to specify the conceptual framework. The results of a cross-sectional survey can describe the association between variables as they exist in a specified sample at a particular time, but they cannot determine cause-and-effect relationships (Hair et al. 1998). Similarly, path analysis can examine the relationships between two or more variables, but can never statistically test for directionality. The directions of arrows in a structural equation model only represent the hypotheses of causality. According to Menard (2002) there are three essential criteria for establishing causal relationships: (1) the variables must co-vary, (2) the relationship must not be attributed to any other variables, and (3) the supposed cause must precede or be simultaneous with the supposed effect in time. With cross-sectional data it is possible to meet criteria one and two, but the third criterion needs a different research methodology. A stronger test of causality would be to use longitudinal data, observing a number of projects as they develop over time. The strongest test of causality is an experiment in which the independent variable is assessed or manipulated before the dependent variable is measured (Hair et al. 1998, Kerlinger 1986, Spector 1994).

This research project used a model development approach, as several modifications to the path models were necessary to arrive at the final models. One problem of this approach is that models confirmed in this manner may not be stable as they have been created based on the uniqueness of an initial dataset (Diamantopoulos and Siguaw 2000). To reduce the possibility of taking advantage of sampling error or ‘capitalizing on chance’, theoretical considerations guided the respecification decisions. The addition and deletion of paths were done only if consistent with theory and face validity. Furthermore, all model modifications steps were described to increase the replicability of this study. To find out whether the relationships hold in different samples, future research should cross-validate the final models using new samples.

Furthermore, results of the integrated model should be treated with caution. Although the initial structure for this integrated model was derived from the individual models for the antecedents and consequences of market information processing, the number of paths in the integrated model is large (28 statistically significant paths) for the available sample size (166

respondents). However, the structure of the significant paths in the integrated model remained the same as in the individual models, with two exceptions: project priority and interdepartmental conflict were not significantly related to the acquisition of customer information. Whether the integrated model holds in a larger sample size should be investigated in a new study.

7.5.3 Measurement issues

NPD performance can be measured either subjectively by asking respondents to assess their performance relative to new product goals, or objectively with absolute values from respondents or secondary sources. Although this research project used subjective measures of NPD performance, Dess and Robinson (1984) advise that where available, objective measures of performance are preferable. On the other hand, Dean and Sharfman (1996) argued that archival sources of data are no less subjective than the assessments of top managers as they are generally the sources for both. In addition, the objective approach may create problems when new products, rather than autonomous companies, are the unit of analysis, as there are often no hard financial data available from published sources for individual NPD projects. Subjective measures of NPD performance have been used extensively in the new product literature and have been shown to be correlated with objective measures of financial performance (Song and Parry 1997).

The product advantage variable was measured as the product's benefits in the eyes of the customer, but the items were judged by managers themselves. The pilot interviews indicated that managers are well able to indicate whether their new product offers new benefits, as they were open about this even when their product offered only a few benefits. It is, however, a limitation of this research that managers were asked to evaluate their own products in the eyes of someone else. Future research may combine customer evaluations with more objective measures such as product test results from independent organizations (such as the consumers' union) to measure product advantage.

The Product Evaluation Laboratory at the Faculty of Industrial Design Engineering in Delft with a consumer panel of nearly 1300 households is an excellent facility for the evaluation of product advantage of consumer products. For evaluating product advantage of industrial products alternative methods may be used. For example, potential customers of industrial products may be questioned during trade-shows, or managers may be asked to send parts of their questionnaires about product advantage to their customers. By combining these methods, product advantage could measure product benefits from the customer's perspective in a more reliable way.

The measures for the acquisition and dissemination of market information were adapted from Jaworski and Kohli's (1993) market orientation construct. However, this

measurement instrument has been criticized as it would only measure customer-led activities and could lead to the development of too many line-extensions and me-too products (Narver, Slater and MacLachlan 2004). In addition, several alternative conceptualizations of the market orientation construct have been developed. For example, Jaworski, Kohli and Sahay (2000) distinguish between a market-driven and driving markets approach of market orientation. Similarly, Narver et al. (2004) introduced a responsive and proactive variant of a market orientation. Together, these advances suggest that using a traditional market orientation scale for the measurement of market information processing in high-tech NPD may sometimes be problematic. However, recent findings indicate that a market orientation measure based on this traditional conceptualization of the market orientation construct facilitates a balance between customer-led incremental innovation and lead-the-customer radical innovation (Baker and Sinkula 2007). Atuahene-Gima et al. (2005) tested the differential effects of a responsive and a proactive market orientation and found that a proactive and a responsive market orientation both enhance new product program performance. The findings of the present research project showed that the acquisition and dissemination of market information based on this responsive measure of market orientation were positively associated with product advantage and NPD performance of high-tech products.

Neither of the market information processing variables in this research project explicitly measured the interpretation of market information. Sinkula et al. (1997) explain that before an organization can act on the information it generates and disseminates, it must be interpreted. Similarly, Daft and Weick (1984) modeled learning processes in organizations, as scanning (data collection), interpretation (giving meaning to the data), and learning (taking action on the information and actually using it). According to Huber (1991), information interpretation is the process by which distributed information is given one or more commonly understood meanings. As the interpretation of market information is determined by managerial mental models, it is more difficult to measure interpretation than, for example, the acquisition and dissemination of market information (Sinkula et al.1997). Perhaps, the inclusion of a good measure for the interpretation of market information could have changed the outcomes of this research. For example, the omission of this variable in the market information processing model may have caused the direct relationship between the acquisition of market information and product advantage. Future research should develop a reliable and valid scale for the interpretation of market information that can be used in studies on market information processing.

Another limitation refers to the measurement of different types of customers. During the feed-back seminar there was some discussion on which customers should be selected to gather customer information. One practitioner explained that in his company (a supplier of

minivan components) customer information from end-users was filtered through different layers of customers such as dealers and manufacturers. Apparently there was only limited direct contact with end-users. Another manager explained that in his company it had become a rule that end-users were involved in the design process, to prevent that the information would be filtered. Measurement items for the acquisition of market information in the questionnaire distinguished between potential customers and end-users. However, no distinction was made between other types of customers, such as retailers or dealers. Therefore, future research may improve the measurement instrument of information acquisition by including questions about different types of customers.

7.6 Conclusions

Despite these limitations, this research project made several contributions to the extant literature. The main conclusion that can be drawn from the results is that market information processing is important for developing high-tech products. Different components of market information processing show differential, but all positive, relationships with new product advantage and new product performance. Although some authors have suggested that market information use likely is detrimental for developing high-tech products, the findings of this research project suggest that gathering, disseminating and using market information in NPD are associated with improved advantage and performance for high-tech products. Therefore, NPD managers must stress the importance of each of these individual components of market information processing during high-tech NPD.

Second, the findings provide support for the temporal structure of the flow of information from acquisition to dissemination and into use. The acquisition of customer and environmental information were both positively related to the dissemination of market information, which in turn was positively related to the use of market information. Previous empirical research has only considered the extent to which market information is used overall in the project. This research project investigated how the extent in which market information is used in each of the different stages of the NPD process relates to outcomes. As a result, this research project showed the consequences of market information processing in a more detailed way than previous studies.

Third, this research project showed that turning customer information into innovation is different from turning environmental information into innovation. Both types of information are gathered differently and they also act differently. Importantly, collecting customer information and gathering environmental information both influence the use of market information directly. This research, therefore, shows the importance of acquiring customer and business environmental information and their separate effects on using the information in different stages of NPD. As a result, developers should search actively for both types of

information. The example of Segway illustrates the importance of gathering customer and environmental information in NPD. Important issues during this project were its confidentiality and the international government regulations on the allowance of vehicles on sidewalks. Instead of stressing secrecy, the project would have benefited if developers were allowed to speak earlier with lead users such as police officers and airport personnel. In addition, environmental information about government regulations would have been helpful during the project, because this could have made the Segway drive legally on the sidewalk earlier.

Fourth, project priority is a beneficial project urgency characteristic for market information processing in high-tech NPD. Project priority was positively related to the acquisition of customer and environmental information and to disseminating market information. These findings confirmed that project priority is relevant for the study of market information processing, as suggested in the exploratory interviews with practitioners.

Fifth, both formalization and interdepartmental conflict at the company level were found to be related to market information processing at the NPD project level. Both variables were associated with the acquisition of market information. Previous research did not find statistically significant relationships between the acquisition of market information and formalization or interdepartmental conflict. Therefore, this research project adds to existing knowledge that formalization and interdepartmental conflict are important company structural characteristics for the acquisition of market information in high-tech NPD.

Sixth, this research project investigated company cultural characteristics for their potential effects on market information processing in high-tech NPD. The results showed that one aspect of a cultural market orientation (measuring market orientation) and a new variable called flexibility to new products were related to market information processing at the NPD project level. These findings confirm that cultural characteristics at the company level influence market information processing behaviors at lower levels of the organization.

Finally, this research investigated the above mentioned sets of antecedents to market information processing and found that some project and company characteristics are more important than others in influencing market information processing in high-tech NPD. Previous research on market information processing has not studied these three sets of antecedents simultaneously. The results, therefore, provide new insight into which factors contribute to, or act as barriers against, market information processing in high-tech NPD.

Summary

Market Intelligence for Product Excellence

Successful new products are important for companies' growth and profitability. Over the years many researchers have investigated the question how new product performance can be increased. One of the factors contributing to successful new product development (NPD) is market information processing (e.g., Atuahene-Gima 1995, Cooper en Kleinschmidt 1987, Griffin en Hauser 1993, Ottum en Moore 1997).

Market information processing is defined as the acquisition, dissemination and use of information about needs and preferences of both current and future customers as well as exogenous factors such as government regulation, technology, competitors, and other environmental forces, that may influence those needs and preferences. The positive influence of market information processing on new product performance can be explained as companies that listen to the market are better able to develop new products that satisfy the needs of future customers and are different from competing products. Therefore, prospective customers are more inclined to purchase these products.

Market information processing may not always lead to higher new product performance. The positive effects of market information processing during the development of high-tech products have been doubted. High-tech products are defined as innovative products that are developed in turbulent environments where technologies move quickly and markets are uncertain. According to some researchers it is better to not process market information for high-tech products because it may lead to less innovative products or a focus on current customers (e.g., Christensen and Bower 1996, Tauber 1974). On the other hand, many arguments are in support of market information processing because it has the ability to improve new product performance, also for new high-tech products.

The above mentioned controversy about the possible effects of market information processing for high-tech products was the primary reason for instigating this research project. A focal research question is therefore, what are the consequences of market information processing during high-tech NPD. In addition, it has been found that many companies experience difficulties with market information processing in high-tech NPD. Frequently, market information is not acquired, if the information is acquired, it is often not disseminated, or information is not used if it has been shared. In other words, market information processing can be improved in many cases. A second important research question is therefore, what are the antecedents of market information processing during the development process of new high-tech products.

To answer these questions the current research develops a conceptual framework based on a review of the literature and the findings of exploratory interviews with practitioners. The model is empirically specified based on the responses of 166 NPD managers to a mail survey. The results were discussed with some of these managers during a feedback seminar. Below, chapter summaries present these individual components of this research.

Chapter 2 summarizes the literature to identify potential antecedents and consequences of market information processing during high-tech NPD. First, the chapter describes NPD performance as the ultimate dependent variable. NPD performance is defined as the extent to which a new product has achieved its consumer-based, financial, and technical or process-based objectives. The extant literature on success and failure factors in NPD has shown that product advantage is the main driver of NPD performance. Product advantage is defined as the new product's superiority over competing products in the eyes of the customer. If product advantage leads to NPD performance this is called 'product excellence', as a reference to the title of this thesis.

Elements of the resource based view of the firm (RBV) are used to theoretically link market information processing and NPD to product advantage. To distinguish between the different stages in NPD projects a generic three-stage model of NPD is presented consisting of predevelopment, development and commercialization stages. One advantage of this generic model is that it makes the number of stages in NPD more manageable to conduct research on market information processing across different projects in a larger amount of firms.

Based on the behavioral market orientation literature and the literature on market information processing it is posed that market information processing consists of the acquisition, dissemination and use of market information and that these activities have a temporal structure. Many researchers have investigated market information processing at the company level, some studied market information processing at the NPD project level, but no studies were found investigating market information processing as the acquisition, dissemination and use of market information in different stages of NPD.

The chapter ends with an overview of potential antecedents of market information processing. Three company structural characteristics (formalization, centralization and interdepartmental conflict) and three company cultural characteristics (cultural market orientation, entrepreneurial orientation and willingness to cannibalize) are identified from the literature.

The objective of chapter 3 is to find additional antecedents of market information processing in high-tech NPD through interviews with practitioners. First, the findings of 11 exploratory interviews with NPD managers in different companies are presented. It is shown

that the majority of the companies experience difficulties with market information processing. Furthermore, improving the acquisition and dissemination of market information increased the use of market information in some companies. Potential antecedents of market information processing that were found in the interviews are project priority, time pressure, and R&D dominance. The findings in the case-study on the development of the first car navigation system elaborate on the difficulties of processing market information in the early stages of NPD. The findings also indicate the potential relevance of two antecedents: time pressure and R&D dominance.

Chapter 4 presents the conceptual framework of this research and discusses the relationships between the different groups of variables in the model. The chapter starts with developing hypotheses for the relationships between market information processing, product advantage and NPD performance. Subsequently, the hypotheses for the relationships between antecedents and market information processing are presented. For reasons of efficiency, the individual components of market information processing are treated as one integrated construct in the hypotheses for the antecedents. The antecedents are grouped into three sets of variables: project urgency characteristics, company structural characteristics and company cultural characteristics.

Chapter 5 explains the research methodology that was used to empirically specify the conceptual framework. A mail survey research approach was used to collect data on 166 NPD projects. Before sending the questionnaires, the research instrument was extensively pre-tested with pilot-interviews (n=9) and a pilot-survey (n=46). After discussing the research method, the chapter describes the operationalization of the variables. Most variables in the questionnaire were measure with multi-item scales. After validating the measures it turned out that three variables were more complex than originally expected. Acquiring market information splits into acquiring customer information and acquiring environmental information. The NPD performance measure consists of two elements: market/financial success and time/cost efficiency. Cultural market orientation breaks-up into measuring market orientation and implementing market orientation. To investigate differential relationships these dimensions are further treated as distinct variables. The variable entrepreneurial orientation is removed from all further analyses, because it did not satisfy the requirements of reliability and validity.

Chapter 6 presents the results of the empirical specification of the conceptual framework. Path analysis is used for model specification and composite measures are used for the different variables. The first path model investigates the consequences of market information processing. After several model respecifications a final structural path model results with good fit indices. In total, six of the ten expected relationships are confirmed and

four new relationships are found. The antecedents of market information processing are analyzed in three separate path models and are finally combined into one integrated model.

Chapter 7 discusses the results of this research and provides managerial implications. In addition, it addresses the limitations of this research and identifies directions for future research. The main finding of the current research is that market information processing in high-tech NPD has a positive influence on both product advantage and NPD performance. This finding contradicts previous studies doubting the usefulness of market information processing for high-tech products. Managers involved in high-tech NPD projects are recommended to monitor that sufficient market information is gathered during the entire project, guarantee that by stimulating the dissemination of market information, all project members keep posted on important market developments, and to encourage the use of market information starting from day one. Enablers of market information processing are increasing the priority of a project within the organization, formulating rules that may stimulate market information processing, enhancing co-operation between different departments and having a market oriented culture. However, absence of these antecedents should never be an excuse to restrain from market information processing in high-tech NPD.

Samenvatting

Marktintelligentie voor product excellentie

Succesvolle nieuwe producten zijn belangrijk voor bedrijven om te kunnen groeien en winstgevenheid te laten zien. In de loop der jaren hebben talrijke onderzoekers zich bezig gehouden met de vraag hoe de prestaties van nieuwe producten kunnen worden vergroot. Eén van de factoren die een bijdrage levert aan succesvolle productontwikkeling is het verwerken van marktinformatie (vb., Atuahene-Gima 1995, Cooper en Kleinschmidt 1987, Griffin en Hauser 1993, Ottum en Moore 1997).

Het verwerken van marktinformatie is gedefinieerd als het verzamelen, verspreiden en gebruiken van informatie over wensen en behoeften van zowel huidige als toekomstige klanten en exogene factoren die hierbij van invloed kunnen zijn, zoals overheidsregulering, technologische ontwikkelingen en concurrenten. De positieve bijdrage van het verwerken van marktinformatie aan de prestatie van nieuwe producten kan worden verklaard doordat bedrijven die naar de markt luisteren, beter in staat zijn hun producten af te stemmen op behoeften van toekomstige klanten en deze producten beter weten te onderscheiden van concurrende producten. Hierdoor zijn potentiële klanten eerder geneigd tot aanschaf van deze producten over te gaan.

Het verwerken van marktinformatie hoeft echter niet in alle gevallen tot positieve resultaten te leiden. Zo worden de positieve effecten van het verwerken van marktinformatie bij de ontwikkeling van high-tech producten vaak in twijfel getrokken. High-tech producten zijn gedefinieerd als innovatieve producten die worden ontwikkeld in turbulente omgevingen met snel veranderende technologieën en veel marktonzekerheid. Volgens sommige onderzoekers is het beter om bij high-tech producten geen marktinformatie te verwerken omdat dit kan leiden tot de ontwikkeling van minder innovatieve producten of een focus op bestaande klanten (vb., Christensen en Bower 1996, Tauber 1974). Aan de andere kant, zijn er veel argumenten voor het verwerken van marktinformatie omdat hierdoor de prestatie van nieuwe producten kan worden vergroot.

De bovenstaande controverse over de mogelijke effecten van het verwerken van marktinformatie bij high-tech producten is de eerste aanleiding geweest voor het opzetten van dit promotieonderzoek. Een centrale onderzoeksvraag is daarom wat de effecten zijn van het verwerken van marktinformatie tijdens de ontwikkeling van nieuwe high-tech producten. Daarnaast is gebleken dat veel bedrijven problemen ondervinden bij het verwerken van marktinformatie tijdens high-tech productontwikkeling. Het verzamelen van marktinformatie wordt vaak achterwege gelaten, of als informatie wel verzameld is, wordt deze vaak niet gedeeld, of de informatie wordt niet gebruikt en wel gedeeld. Met andere

woorden, het verwerken van marktinformatie kan in veel gevallen worden verbeterd. De tweede vraag die in dit onderzoek daarom centraal staat is welke factoren (antecedenten) zorgen ervoor dat marktinformatie wordt verwerkt tijdens de ontwikkeling van nieuwe high-tech producten.

Voor de beantwoording van deze onderzoeksvragen wordt op basis van een literatuuroverzicht en de uitkomsten van exploratieve interviews met managers uit de praktijk een conceptueel raamwerk opgesteld. Het resulterende model wordt met behulp van vragenlijstenonderzoek onder 166 productontwikkelingsmanagers empirsch gespecificeerd. De resultaten van het onderzoek zijn vervolgens doorgesproken met de desbetreffende managers tijdens een feedback seminar. De onderstaande samenvattingen van de verschillende hoofdstukken behandelen de individuele onderdelen van het onderzoek.

In hoofdstuk 2 wordt de literatuur samengevat om mogelijke antecedenten en consequenties van het verwerken van marktinformatie tijdens high-tech productontwikkeling te identificeren. Allereerst wordt de prestatie van nieuwe producten beschreven als belangrijkste afhankelijke variabele. De prestatie van nieuwe producten wordt gedefinieerd als de mate waarin een nieuw product zijn klant-gerelateerde, financiële, en technische of proces-gerelateerde doelstellingen behaalt. Uit de omvangrijke literatuur over succes en faalfactoren is gebleken dat productvoordeel de belangrijkste verklarende variabele voor de prestatie van nieuwe producten is. Productvoordeel wordt gedefinieerd als de mate waarin een product volgens klanten superieur is ten opzichte van concurrerende producten. Als productvoordeel leidt tot een hogere prestatie van nieuwe producten wordt dit ‘product excellentie’ genoemd als verwijzing naar de titel van dit proefschrift.

Met behulp van de resource based view of the firm (RBV) wordt een theoretisch kader gevormd waarmee het verwerken van marktinformatie binnen de productontwikkeling kan worden verbonden aan productvoordeel. Om bij productontwikkeling onderscheid te maken tussen de verschillende fasen in projecten wordt een generiek 3-fasen model gepresenteerd bestaande uit een voorontwikkelingsfase, een ontwikkelingsfase en een commercialisatiefase. Een voordeel van dit generieke model is dat hiermee het aantal stappen meer hanteerbaar wordt om onderzoek te doen naar het verwerken van marktinformatie bij een groot aantal bedrijven en verschillende projecten.

Op basis van de gedragsmatige marktoriëntatie literatuur en literatuur over het verwerken van marktinformatie wordt gesteld dat de verwerking van marktinformatie bestaat uit het verzamelen, verspreiden en gebruiken van marktinformatie en dat deze activiteiten elkaar opvolgen in de tijd. Hoewel het verwerken van marktinformatie veelvuldig is onderzocht op het niveau van het bedrijf en in mindere mate ook op het niveau van productontwikkelingsprojecten, zijn er tot dusverre geen studies gevonden waarbij het

verwerken van marktinformatie wordt onderzocht in de verschillende fasen van de productontwikkeling.

Het hoofdstuk eindigt met een overzicht van mogelijke antecedenten voor het verwerken van marktinformatie. Met betrekking tot de organisatiestructuur worden de variabelen formalisatiegraad, centralisatiegraad en de mate van conflict tussen verschillende afdelingen geïdentificeerd. Voor de eigenschappen van een organisatiecultuur zijn dit de variabelen culturele marktoriëntatie, ondernemersoriëntatie, en de bereidheid tot kannibaliseren.

Hoofdstuk 3 heeft als doel om door middel van interviews met mensen uit de praktijk aanvullende antecedenten te vinden voor de verwerking van marktinformatie tijdens high-tech productontwikkeling. Als eerste worden de resultaten van 11 exploratieve interviews met productontwikkelingsmanagers bij verschillende bedrijven besproken. Het blijkt dat veel van de ondervraagde bedrijven problemen ervaren bij het verwerken van marktinformatie. Daarnaast lijkt bij sommige bedrijven een verbetering van het verzamelen en verspreiden van marktinformatie tot een toename van het gebruik van marktinformatie te hebben geleid. Mogelijke antecedenten voor het verwerken van marktinformatie die uit de interviews volgen zijn de prioriteit van een project, de mate van tijdsdruk en R&D dominantie. In de case-study over de ontwikkeling van het eerste autonavigatie-systeem wordt uitgebreid ingegaan op de moeilijkheden van het verwerken van marktinformatie in de vroege fasen van high-tech productontwikkeling. De bevindingen van de case-study duiden eveneens op de mogelijke relevantie van de variabelen tijdsdruk en R&D dominantie.

Hoofdstuk 4 presenteert het conceptueel raamwerk dat centraal staat in dit onderzoek en behandelt de relaties tussen de verschillende groepen variabelen in het model. Het hoofdstuk begint met het formuleren van hypothesen voor de effecten van het verwerken van marktinformatie op de afhankelijke variabelen productvoordeel en de prestatie van nieuwe producten. Daarna worden de hypothesen over de relaties tussen antecedenten en het verwerken van marktinformatie gepresenteerd. Om efficiency redenen wordt de verwerking van marktinformatie voor de hypothesen over de antecedenten beschouwd als een geïntegreerd construct zonder afzonderlijke componenten. De antecedenten zijn ingedeeld in drie blokken met variabelen: project urgentie karakteristieken, structurele karakteristieken van een onderneming en culturele karakteristieken van een onderneming.

In hoofdstuk 5 wordt de gehanteerde onderzoeksmethode toegelicht om het conceptueel raamwerk empirisch te specificeren. Door middel van een vragenlijst zijn gegevens verzameld over 166 productontwikkelingsprojecten. Voordat de vragenlijst werd uitgestuurd is deze uitgebreid gepretest met behulp van pilot-interviews (n=9) en een pilot-survey (n=46). Na de bespreking van de onderzoeksmethode wordt de operationalisering van de variabelen uitgelegd. De meeste variabelen in de vragenlijst zijn gemeten met multi-

item schalen. Na validatie van deze meetschalen blijkt dat drie variabelen complexer zijn dan in eerste instantie gedacht. Het verzamelen van marktinformatie bestaat uit het verzamelen van klantinformatie en omgevingsinformatie. De prestatie maatstaf valt uiteen in markt/financieel succes en tijd/kosten efficiëntie. Culturele marktoriëntatie blijkt te bestaan uit een maatstaf voor het implementeren van marktoriëntatie en een maatstaf voor het meten van marktoriëntatie. De variabele ondernemersoriëntatie wordt voor de verdere analyses verwijderd, omdat deze variabele niet voldoet aan eisen van betrouwbaarheid en validiteit.

Hoofdstuk 6 presenteert de resultaten van de empirische specificatie van het conceptueel raamwerk. Voor de specificatie wordt gebruik gemaakt van padanalyse waarbij de verschillende variabelen worden gemeten door hun samengestelde items. In het eerste padmodel worden de effecten van het verwerken van marktinformatie onderzocht. Na herspecificaties resulteert een model met goede fit indices, waarin zes van de tien verwachtte relaties worden bevestigd en vier nieuwe relaties worden gevonden. De antecedenten voor het verwerken van marktinformatie worden in drie afzonderlijke modellen geanalyseerd en tenslotte samengevoegd in één geintegreerd model.

Hoofdstuk 7 bespreekt de resultaten van dit onderzoek en voorziet deze van praktische implicaties. Tevens worden tekortkomingen van het onderzoek getoond en worden mogelijke oplossingen voorgesteld om hier in toekomstig onderzoek mee om te gaan. De belangrijkste bevinding van het huidige onderzoek is dat het verwerken van marktinformatie tijdens de ontwikkeling van nieuwe high-tech producten een positieve bijdrage levert aan zowel productvoordeel als de prestaties van nieuwe producten. Hiermee worden argumenten over mogelijke negatieve consequenties van het verwerken van marktinformatie bij high-tech productontwikkeling ontkracht. Aan managers die betrokken zijn bij de ontwikkeling van high-tech producten wordt geadviseerd er op toe te zien dat tijdens het project genoeg marktinformatie wordt verzameld, er voor te zorgen dat door het verspreiden van marktinformatie alle projectleden op de hoogte zijn van belangrijke marktontwikkelingen, en het gebruik van marktinformatie vanaf de eerste dag van een project tot en met de marktintroductie te stimuleren. Factoren die hierbij kunnen helpen zijn het vergroten van de prioriteit die binnen het bedrijf aan het project wordt gegeven, het opstellen van regels die het verwerken van marktinformatie bevorderen, het stimuleren van samenwerking tussen verschillende afdelingen het hebben van een marktgerichte bedrijfscultuur. Het ontbreken van deze bevorderlijke condities moet echter geen reden zijn om af te zien van het verwerken van marktinformatie bij high-tech productontwikkeling.

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Appendices

Appendix 1: Company profiles and interview outcomes

Consumer Electro Co. is one of the world's biggest electronics companies with more than 150,000 employees in over 60 countries. We interviewed a business development manager for creative display solutions on the development of a new device for watching movies in cinema format at a display with the size of a pair of glasses. Although the project used a lot of market research, the product was never introduced to the market and was put on hold after the predevelopment stage. The product was too expensive to introduce and there was no market demand for it.
Several important insights were derived from this interview. First, the product development process started with marketing communications to find out how the product communicated its functional and emotional benefits to consumers. Furthermore, competitors were considered as partners for learning together how a new market had to be created. At the time that the interview was held, the company was moving from an engineering and R&D driven company to a more market-oriented and consumer-driven company. Market research was used to find applications for the new technology and to estimate whether there was a potential market. Often the results of market research were 'inconclusive' and could not be used for decision-making.

Mobile Communications Inc. is a division of one of the world's largest companies in the field of electrical engineering and electronics. The division is a large supplier of telecommunications infrastructure offering networks and communications devices. The interview with a product marketing manager focused on the development process of mobile phones for the third generation mobile network (UMTS). The company used a formalized NPD process with milestones.
The interview showed that project priority and time pressure were important determinants of market information processing. Market research was a standard procedure in the development process. Resources had to be allocated between different projects. If a project was interesting enough it became more important and received more resources. Short product life cycles increased time pressure and necessitated finding compromises between doing market research and taking decisions.

Mobile Services Inc. is the mobile phone division of one of the largest Dutch providers of telecommunications services. The interview with two market researchers focused on the development process of new services for the third generation mobile network. This new mobile network has a higher capacity for data transportation and allows the use of more advanced services. The market research department employed 400 researchers, of which one quarter was involved in customer research and three quarters were involved in technical research. In the interview it was found that market researchers used several techniques to disseminate and increase the use of market information. Furthermore, it was found that the priority of a development project could enhance the acquisition of market information. Also, project time pressure decreased the use of market information and had a negative influence on the design of customer research. Finally, R&D dominance resulted in less effective market information processing as project leaders would sometimes use only market information that suited their proposed technological platform.

Nordic Telecom Inc. is a large multinational telecommunications company with more than 100,000 employees in 140 countries. The interview (with a key design coordinator) concerned the development of a high-tech device for the home communication market that combines internet access with telephony and e-mail. The device has a color touch screen and communicates wirelessly with a base station through Bluetooth. The NPD-process has taken 4 to 5 years and has been broken up into several stages and gates to keep the project manageable. The product attracted considerable attention when it was presented at the CeBIT exhibition in Hannover, but was never commercially launched, as the company decided that the

Nordic Telecom Inc. (Continued)
market was not mature enough for this device. Important issues in the interview were the accessibility and dispersion of market information and the dominance of the R&D function. The accessibility of information was restricted because not all employees had access to a common intranet and product marketing decided who had access to certain market information products. Late adjustments in product specifications led to pressure on the relationship between marketing and R&D.

SmartAgent.com is an Internet software company that was founded by a small team in 1999. The interview with two of the founders (financial officer and lead developer) focused on the development process for an intelligent software agent. This product helps users to search and shop on the internet and it adapts to personal preferences and behaviors of the user. Before the product was launched on the consumer market a beta test took place. The NPD-process had no formal stages and decision-gates, but followed a sequence that was rather intuitive.
During the interview some important issues came up, namely the focus on technology in the first part of the development process and the use of customer information from beta testing. The strong belief in new technology characterized the development process and led to less customer attention in the early stages. A beta test revealed the shortcomings of the product and helped to attune the product more to customer needs.

Car Communications Inc. is one of the world's leading suppliers of electronics, electrical systems and mechatronics to the automotive industry. In 2001 the company generated sales of EUR 5.7 billion with 45,000 employees. The division for car navigation systems has 1,500 employees and it is present in 80 countries in both B-to-B and B-to-C markets. The interview focused on the development process of the car navigation system.
In the interview it was found that the use of market information contributed to several important product attributes, especially in later stages of the NPD process. Although the first generation of the car navigation system was mainly driven by technological developments, a strong market vision was essential in finding resources for the project. Market uncertainty in the early stages of development was partly resolved by building early prototypes and showing them to top management, potential customers and the press. Time pressure was present in several stages of the development process and led to more efficient market information processing in this case. Project members had direct access to customer information because they had to participate in task-forces with customers to deal with time pressure.

Biometric ID is a subsidiary of a technology group with 40 enterprises, employing over 1000 people in more than 14 countries in Europe and the US. Biometric ID is originally a spin-off from a technical university and has evolved from an R&D entity into a commercial company. The interview (with a project manager) was about the development of an intelligent pen that recognizes a user and determines his/her identity. The pen is offered to the business-to-business market for fraud prevention, security and cryptography in internet transactions.
The NPD-process consisted of a research phase and a development phase. The company uses beta tests for evaluating and improving the final product. Important issues discussed were the tension between marketing/sales and R&D and the role of project management as a mediating party. The task of project-management is to negotiate between R&D and marketing/sales and to direct them together towards a common goal.

Embedded Electro Co. is a business unit of an international engineering company that was founded in 1992 and headquartered in The Netherlands. The business unit specializes in the design and production of embedded systems, telecommunications systems and remote management systems. The interview focused on the design of telecommunications equipment, used for routing telephone and data traffic. These, so called, diallers allow firms to correctly route telecom traffic by way of number recognition. The product was developed based on a customer's request for routing fax traffic. Market developments and technological limitations changed the direction of the project into phone traffic. The new product was made specifically

Embedded Electro Co. (Continued)
for one customer and then made standard for other customers. Therefore, customer requirements were clear from the beginning. Competitor information was deemed less important. Once a week all projects were discussed to get an overview of all progress and to disseminate information. During development the gathered information was bundled and stored in an electronic knowledge library. By doing this the information was also available for future projects.

Thermo Technology Inc. was founded in 1992 and specializes in product development for third parties in the field of heating technology and energy transportation. After several years of working for external customers the company decided to initiate an internal new product development project in 1999. The interview focused on the development process of an anti-theft smoke machine for shopkeepers. After a burglary alarm, this machine creates a dense smoke screen to protect expensive goods, such as jewellery, against burglars. The company used the same development process that was used for external customers. The company went bankrupt in 2002.
Important issues discussed in the interview were the project's priority compared to existing projects and the influence of a standardization institute on cycle time. It was explained that the self-initiated new product development project sometimes moved to the background because other projects for existing customers were considered more important. The acquisition of market information for this project occurred in an ad-hoc manner at tradeshows and in conversations with existing customers and competitors. The company had to wait for a go from a standardization institute because there were no existing norms for this type of product. Combined with the low priority this resulted in a long delay of the project.

Vision Equipment Inc. was founded in 1982 as a spin-off of a technical university and operates with more than 180 employees as a world leader in vision technology and a supplier for the semiconductor industry in Europe, US, Japan and South East Asia. The product lines include machine vision systems for the optical inspection of semiconductor components. Machine vision systems are computer-based image analysis tools that replace human inspection for tasks that require high visual accuracy and speed. The interview focused on the development of a new system for the visual control of chips, before they are used in various applications such as PC's, cars, mobile telephones and digital cameras.
Some issues that appeared important were the technological background of the company and the co-operation with customers during NPD. The roots of the company caused a focus on technology in the first years, which changed to a market orientation in order to commercialize the products. The company now works together with customers from the design phase onwards, which is possible because of the limited number of (B-to-B) customers. The combination of a technological orientation with a market orientation enables the company to keep research efforts in tune with market needs.

Visual Machinery Inc. is a developer of machine vision systems which are integrated in their business-to-business (B-to-B) customers' industrial processes. In a period of five years, the company had grown from 11 employees to 23 employees with sales revenues of five million Euros. The interview with a general manager focused on the development process for a visual inspection system of identification codes on laboratory test tubes. In close co-operation with a customer and a supplier of specialized electronics, Visual Machinery Inc. developed a code reader and a unique code with matrix dots that are laser-printed on a test-tube. The code reader combined with the unique code allows the reliable detection of test tubes. At the time of the interview, the reliable detection of test tubes with veterinary blood samples became more important as a result of public fear for mad cow disease (BSE). One issue that was raised in the interview was the amount of time pressure during the development process, caused by fast developments in the semiconductor industry. The company used its technological experience to deal with these changes.

Note: The real names of the companies have been disguised for confidentiality reasons.

Appendix 2: Topics and interview questions of exploratory interviews

1. Introduction and goal of the research project

- Explain background of the research project
- Explain objective of the research project
- Explain high-tech products and market information processing

2. General company and respondent information

- Background of the company
- Organizational structure
- Type of products
- Function and career path of respondent
- Responsibilities of respondent during NPD
- Selection and description of product for interview

3. New product development process

- Describe NPD-process from idea until market introduction
- Describe the NPD-project team, which people/departments?
- Co-operation between marketing, R&D and other departments in NPD?
- How long did the team exist/did the composition change?
- Which activities took place during the selected NPD-project?
- Which problems have occurred during the selected NPD-project?

4. Acquisition of market information

- Which market-players have been observed during the NPD-project?
- How was market information acquired during the NPD-project?
- Where did market information came into the organization?
- How did the NPD-team gather market information?

5. Dissemination and storage of market information

- After the acquisition, where has market information been stored?
- How was market information disseminated to the project team?
- To what extent was market information accessible to everyone in the team?
- How did team-members communicate, how did they share information?

6. Use of market information

- What actions have been taken based on market information?
- How useful was the information for the development of a high-tech product?
- What organizational factors had an influence on the use of market information?

7. Summary

Appendix 3: Summary statistics and Cronbach's alphas pilot mail survey (n=46)

	Mean*:	SD:	Cronbach's alpha:
New product outcomes			
NPD Performance	3.12	.98	.96
Product Advantage	3.74	.60	.77
Market Information Processing			
Use of Market Information in Predevelopment	3.40	.75	.87
Use of Market Information in Development	3.27	.73	.88
Use of Market Information in Commercialization	2.98	.83	.87
Dissemination of Market Information	2.88	.86	.86
Acquisition of Market Information	3.21	.64	.84
Project Urgency Characteristics			
Project Priority	3.50	.73	.83
Project Time pressure	3.06	.73	.80
Company Structural Characteristics			
Formalization	2.94	.59	.72
Centralization	1.99	.58	.86
Interdepartmental Conflict	2.70	.60	.76
Company Cultural Characteristics			
Cultural Market Orientation	3.10	.64	.85
Entrepreneurial Orientation	3.28	.60	.77
R&D Dominance	3.18	1.09	.83
Willingness to Cannibalize	3.18	.63	.73

* Entries are based on a 5-point scale with '1' = completely disagree and '5' = completely agree.

Appendix 4: Answers to open questions on product description and product benefits

	Product description	Product benefits
1	Coloring agent for universal color paste.	Broad applicability, renewable, optimal color development.
2	Telemetric system for managing pumping stations of polders from a distance.	Functionality, technology.
3	Inverted cargo castor for sorting decks in the airport industry.	Easy to assemble, cheaper replacement.
4	Package machine for free-range eggs.	Low cost-price, multifunctional, small size.
5	Screw-cap for milk, juice or yoghurt packages.	Ultrasonic seal application, re-lockable cap, ease-of-use.
6	Protection hose for export market.	Based on market needs, adjusted production process.
7	Agricultural machine for receiving farm products.	Power transport, distance to cleaning.
8	Volume tuning knob for ventilation technique.	Speed of assembly.
9	Compact solution for assembling boxes with plastic bags.	Broad applicability, small size.
10	New drug, low dose aspirin.	Solvent, reaction in a tablet.
11	Modular cardboard box assembly machine.	Modularity, assembly system for rectangular boxes.
12	Illumination equipment for landing zones of airports.	Reliability, safety, low maintenance cost, energy efficiency, low installation cost, control system.
13	Synthetic material to replace steel components.	Only manufacturer who makes this material.
14	Magnesium hydroxide suspension in water used for desulphurization.	Delivery of material and collection of waste, removing harmful sulphur pollution from gases.
15	Polyester top-layer for baking dishes.	New preparation method and additives.
16	Mid range autotransformer 230 KV DETC for the U.S. market.	Flexible solution, modular components.
17	-	-
18	Spin drier for vegetables.	Short processing time, better dry system, hygienic design, low price, easier to use.
19	Digital ink.	Better answer to customer needs.
20	New generation carbon black tires.	Lower rolling loss, improves wear resistance, maintains wet traction.
21	Easy opening pouring aid for coffee milk packages.	Production process with moulding technology, prevent spilling.
22	System that integrates software products.	Flexible, offers a framework, vertical integration of different software products.
23	Extruded cat food.	99% product acceptance, first mover advantage.
24	Accommodation for meat-producing breed.	Space-saving, more animals per square meter ground surface, better climate control, energy efficiency.

25	Offshore wind turbine.	Offshore application, all necessary electronic equipment.
26	Suction drainage for dust particles in wood manufacturing industry.	System can be added to existing systems, central storage of dust particles.
27	Monofilament cotton for artificial grass.	Similarity to natural grass, new composition of materials, unique production process.
28	Product for automotive industry.	Confidential.
29	Portable stove with French chalk surface.	Satisfies stringent DIN emission norms.
30	Guillotine shearing machine with hybrid driving technology.	Hybrid driving unit, Protection based on 3D finite elements software.
31	Fastring, modular connection technique for assembly and repair of Geophone strings in oil and gas exploration.	Insensitivity to technical disturbances.
32	Software product to adjust office printers to customer needs.	Easy to configure and yet versatile.
33	Nested package with screw cap seal system.	Shock resistant, ergonomics, easy to open, 2-component spray-casting technique, low production price.
34	Transportation mechanism for moving eggs vertically.	New technology, components made with spray-casting technique.
35	Optical oil in water monitor for marine navigation.	Measures parts per million oil in water, not affected by fixed particles in water.
36	Dividing wall for horse stall creep boxes.	Easy installation, high comfort and lower chance of injuries, longer lifespan.
37	Ultrasonic conveyor-belt washer for bakeries.	Better cleaning than other systems.
38	-	-
39	Food supplements glued with fertilizer for cultivating plants.	Presentation format, use of glue.
40	Vertical pump for pumping coolants inside machinery.	Vertical unit, easy to replace, longwearing
41	Outdoor payment-terminals based on industrial PC technology.	Systems runs on XP and TCP/IP technology, possible to run multimedia applications on terminals.
42	Assembly machine for flexography (rotating printing technique).	Flexible carrier of printing blocks, freedom of printing length.
43	Vapour flow meter for the extraction of vapours at gas stations.	Self-calibrating mechanism, 100% efficiency.
44	Compact heat exchange unit with plate-fin technology.	Size, price, speed of manufacturing and delivery.
45	Solar inverter 250W for net-linked application.	Power electronics.
46	New perfume ingredient.	Price/performance advantage.
47	Multi global positioning system.	Wireless system, flexible application.
48	Lily flower root chopper for horticulture industry.	Works on a bed of turning rolls.
49	Production machine for puff pastry.	Price/performance relationship.
50	Dosing and monitoring unit for powder substances.	Hydraulic driving mechanism, less mechanical problems, easy to install.
51	Professional oven.	Microwave partitioning units on separate baking levels.

52	Magnetic handling system for picking up steel components.	Pneumatic system.
53	Switchbox for transformer stations of electricity companies.	No maintenance needed, long lifespan (>20 years), high safety, ready for automation, environmental friendly design.
54	Insulated coating for saw-cutting edge of plate material.	Only one component and one hour drying time.
55	Medical electrical system for eye-surgery.	Keeps eye-pressure constant during operation, control via touch-screen, two different pump systems for eye liquids.
56	-	-
57	Machine for diamond drilling.	Optimizes drilling speed, automatically adjusts drilling speed, adjustable depth of drilling, increases lifespan of diamond drills.
58	Gas cylinder panel with automatic purge option.	Combination of fully automated and hand-controlled, good price/quality relationship, safety.
59	Heat exchange unit.	High effectiveness, programmable ventilation, interior from EPP, design.
60	New development tool for business applications.	100 x higher productivity, pattern-driven generators, fully adaptable by customers, high abstraction level.
61	-	-
62	Green house glass coverage system.	Synthetic mounting instead of aluminium.
63	-	-
64	Machine for combining synthetic tubes automatically.	Automatic attachment, high speed.
65	IP/ATM card for SDH-systems.	Effective transportation of IP/ATM traffic across SDH networks, no need for separate switches or routers, economic advantage for operators, more network traffic for lower costs.
66	Isolated roll containers for transportation of meals between care institutions.	Stainless steel container is glued, less seams, easy to clean.
67	Vertical pump for transportation of polluted fluids.	Can also be used when filled with air, pumps polluted fluids, high material quality, cost saving for customer.
68	Fibre to the home network amplifier.	Price/performance, plug and play philosophy, higher communication speed.
69	Software for noise-measurement near airports.	Modular and easy to configure for each customer, satisfies EU standards, good price/performance relationship.
70	Silent generator.	Low noise level, user friendly, autonomy, environmentally friendly.
71	Hay dryer for agricultural industry.	Speed of drying, Better performance.
72	Deburring and grinding machine.	Fully automated, high performance, multi-functionality, price is a disadvantage (>20% than competition).
73	E-mail system that automatically sends special offers to Airmiles customers when they move to a new address.	Focus on moving event, maintain customers.

74	Fertilizer tank with variable pump driving mechanism.	Pump driving mechanism with two stepless adjustable gears, large volume tank, control unit.
75	Blaster technology, deployed by coiled tubing of a rotating tool which can handle beads to blast a scaled tubing or acid in oil and gas wells.	Designed to withstand a hostile environment, rotating nozzle, no loss of pressure in kinetic energy, non-damaging beads.
76	Dosage machine, doses a requested recipe from 16 raw materials.	First on the market, based on a weighing machine, small container size, low cost.
77	Hydraulic tipping mechanism for power shovels.	Working angle of 40 degrees, compact size, small weight.
78	Administrative software for housing corporations.	Meta-model that can easily be adapted for each customer.
79	Header tank with magnetic valve.	Integrated assembly straps, complete solution, no corrosion, light weight.
80	Cordless hydraulic rescue tool.	Works on a 24V battery, compact and ultra light weight.
81	Multi mover vehicle with laser guns for amusement parks.	Can move 6 persons, no rail guidance, interactive ride control.
82	Package assembly glue.	Different polymer, lower price, more stable at processing temperature of 180 degrees Celsius.
83	Water filtration system.	Low energy consumption, software control, can be used for different applications, standardized low cost.
84	Modular high-speed offset printing machine.	Modularity, flexible driving mechanism, ergonomics, durability, stable print.
85	Ultrasound color scanner with Doppler.	Small high-end color system for the price of a medium system.
86	Cutting-off machine with conveyor-belt.	-
87	Implantable ultra ocular lenses.	Corrects for spherical aberrations caused by the cornea of cataract patients, based on wave-front analysis techniques.
88	Water disinfection based on ultra-violet radiation for horticulture industry.	Existing product for a new market, combat-ready.
89	Underground technology solution for low voltage power distribution.	The unit will not be an obstacle in public areas, impossible that distributor will be flooded.
90	Gas burner based on a new material for closed-circuit radiator.	Surface made of woven metal structure, Flame shape and appearance.
91	Cheese slice machine that removes plastic housing from rectangular cheese.	Due patents no competition, only competition is manual processing.
92	LED signal.	Long product lifespan, low maintenance, same light yield as predecessor.
93	Cool- and heating convector for ceilings.	Compact installation, high capacity, low price, low weight, space saving.
94	Installation for emission-free loading of bulk products.	Combination of different technologies.
95	1800 Bar pressure-sensor for Diesel injection systems in light vehicles.	Unique sensor technology, price/performance relationship.
96	Redesign of frequency-control units for a new generation of power electronic components.	Power between 45 KW and 1500 KW, internal modularization in the full-power range.

97	Ecocool, new cooling concept for rotational offset printing.	Simple concept, smaller cooling rollers, integration of different functions.
98	Java scheduling software.	-
99	Detergent for black and dark-colored clothing.	Unique ingredient for black fixation, special mixture.
100	Aquarelle paint with Teflon coating.	Teflon hardness, without primer on synthetic surfaces, usable as normal paint, appearance of normal paint.
101	New polyethylene with better properties.	Foil made from this material is five times stronger, makes thinner packaging possible, cost saving, environmental friendly.
102	LED-technology for outside use.	Less consumption of current, less maintenance, longer lifespan.
103	Windmill-control unit.	Less wear and tear, more durable.
104	Light weight offset printing unit for paper, foil and aluminium.	Variable printing format, only 10% of the cost of a normal printing unit, every cylinder has its own servo driving mechanism.
105	Fitting for emergency lighting.	Modern design, low height.
106	Child safe tablet container.	Patented child safe system, integrated patient information leaflet compartment.
107	Dough master, dough weighing machine for industrial bakeries.	Reduces damaging of dough structure, weigh precision, production capacity, easy to clean.
108	New pacemaker	Possible to treat heart failures, suitable for patients with combined diseases.
109	Machine for unloading long materials from trucks in rough surroundings.	Excellent driving stability in four directions, fool proof, low maintenance.
110	-	-
111	Potato lifting machine.	Higher capacity, better performance.
112	Software for protecting a network against unwanted email and web-access.	Easy to install.
113	Round bag press (farming machine).	Universal applicability, easy maintenance, friendly design, high capacity.
114	Electronic patient file-system.	Registration of data at the source, easy to integrate, designed form the user.
115	Rotation mechanism for potato/onion crates.	Product friendly, product can not fall to ground and will not damage.
116	Roof ventilation unit for spaces between 0.15 and 3.0 cubical meters.	Simplicity of construction, sharp price-setting, modern design, complete documentation with product information.
117	Program to process and present large amounts of data.	Unique way of data presentation, processing speed.
118	Investment giro account.	Many modular solutions, quickly adjustable, low maintenance costs, complete disclosure to internet, works on more than 200 platforms.
119	Coloring agent preparation.	Does not contain plasticizing agents, high coloring agent content.
120	Gas cooking range with stir-frying unit.	Stir-frying unit can be placed in different positions.
121	Electric motor with built-in frequency control.	Electric transformers have been placed directly on the electric motor.

122	Packaging for lolly-pops.	Fast, hygienic, beautiful, reliable.
123	Gas fireplace with low power.	Easy installation, innovative burner technology, ergonomics.
124	Comfortable electronic magnifying-glass.	All-in-one, manageable, high quality.
125	Electrolytic condenser series.	Proficient at high temperatures, works at high mechanical pressure, solves problems.
126	Flame retarder.	High chemical requirements, special crystallization technique.
127	Composite rollers.	Lighter weight than steel rollers, larger number of critical revolutions, more durable.
128	Java-based event manager to monitor the progression of ICT-supported processes proactively.	Proactive control, One of the first of its kind, increases value-added of customers.
129	Steel chips transportation unit used for turning machines and milling machines.	Better cleaning of coolant, integration of steel chips transportation with coolant filtration, easy to use/understand product.
130	New windmill made from carbon-strengthened synthetics.	Windmill wings of 40 meters, new materials.
131	Data-logger for various units ($kwh/m^3/ºC$).	GSM-communication, multi-functionality.
132	New front-end with update coding.	Additional functionalities, first on the market.
133	Actuator for electronic exterior rear-view mirror.	Technological concept, best in class performance, good price/performance relationship.
134	X-tender batteries with carbon additive.	New battery properties due to carbon fibres, First company to incorporate carbon fibres in active mass.
135	Omni directional microphone unit for hearing aids.	Directional microphone, application-directed design.
136	Machine for dismantling PC's.	New process.
137	Compact fluorescent light bulbs.	High light emission, user friendly, maintenance, long lifespan, excellent price/quality relationship, better than every other solution.
138	Open database based on windows.	Fully integrated, open database, flexible.
139	Machine for the manufacture of aluminium reflector mirrors in tubular lighting boxes.	Worldwide patented.
140	Led-based illumination for photo-dynamic therapy.	No competition.
141	Energy efficient light.	Based on old production platform, better control of light output.
142	Translucent panel and construction adhesive.	Enables invisible adhering, no competition, first translucent construction adhesive.
143	-	-
144	Set of web-services for geographic localization.	First XML-application, best data coverage that is available, web-service can be hosted by customers.
145	Shower sensation, shower product changes from gel into foam.	First shower product that changes from gel into foam.
146	-	More symmetric and constant quality, no need to align products.

147	Software module for administering production recipes.	Can be applied in different industries with small modifications, communicates with process control, ease-of-use, guaranteed link between production and ERP.
148	Motion controller based on network technology.	Open software, advanced motion control, high-speed digital networking technology.
149	Crop protection machine.	Modular European design.
150	Integrated business information system.	Disclosed through intranet, multifunctional, no competitive products.
151	Wheel-slide conveyor-belt transporter.	Assembled from standard modules, short cycle-time, improved maintenance.
152	Aluminium fork-lift jack.	Able to lift 4,000 kg and weighs lighter than 25 kg, design.
153	Measurement instrument.	ATEX/I.S.
154	Free floating piston.	Prevents surface contact and wear-and-tear.
155	Employee self service concept for HRM activities.	Based on web-technology, improves productivity of HRM department, increases individuality and involvement of employees.
156	Photographic offset plate for process chemistry.	Can be used in competitors' processes, no competition.
157	New generation switch-boxes.	Patented box-profile with unique applications.
158	Unpacking machine for coin rolls and -bags.	No competition, unique by combination of technologies, totally new, well-received by the market.
159	Direct e-mail marketing application.	Custom-made, user friendly.
160	New flanges for renovation of sewers.	No excavation needed in 90% of the cases, time-saving, environmental friendly.
161	Web-based e-CRM product.	Recognizable user interface, personalization of user interface, better product acceptance, made in Holland (local knowledge), integrated database, low network capacity .
162	Product for transmission of video, audio and data across different types of glass fibre.	Transmission can be unidirectional and bi-directional, high video quality by 10-bits digital technique.
163	Industrial inkjet printer for printing text on cardboard boxes during production process.	Excellent printing quality, ease-of-use, universal software package.
164	-	-
165	Single-double pallet handles.	Integral hydraulic construction.
166	Magnet for lifting and moving steel objects.	Higher capacity, low weight, compact, modern design, easy-to-use, more reliable.
167	Four-armed jib for agricultural mowing on ditches and verges.	Size of the jib satisfies the Dutch transportation law, no competition.
168	Put-e-light system for sorting goods.	Software and 8 monitors on one pc, magnetic card readers instead of push buttons, operates by using colors.
169	Propeller pump.	Hydraulic design, size.
170	Content management system for website development.	Flexible by the use of authorization model, possible to manage interactive functions.
171	Pallet handling machine for label attachment.	Satisfies EAN norm, cost saving for customers, offers stability.

172	Rotational frequency controlled compressor.	-
173	Demolition and sorting grab bucket for demolition of buildings and sorting of construction waste.	360 Degrees rotation, oil transit through rotator, unique sealing on turning points, two applications: demolition and sorting.
174	Medical bullet shooting device to place small bullets in bones for making pictures of the hinge.	Portable cassette to load bullets, One device for bullets of different sizes, stiffness, dismountable, easy to clean, easy to assemble.
175	Climate control for greenhouses.	Simple control unit, user friendly graphical interface, useful addition to product range.
176	Rooftop for air ingestion and air extraction.	Addition to an existing product.
177	Energy efficient light source for the entertainment industry.	High power light with fast electric discharge, high intensity of optical system, possible to control light at high temperatures, less cooling and less noisy.
178	Vegetables and fruit sorting machine.	-
179	Arm pad with air cushion for office chair.	Produced on a 2-component machine, choice of materials, comfortable arm pad for a reasonable price.
180	-	-
181	Casing running tool for raising and dropping drill pipes on oil platforms.	Reduction of the number of manual handlings, higher safety, can also be used for coupling and decoupling drill pipes.
182	New rack for storage purposes in offices and archives.	Full-automatic assembly from 1 part, cost price reduction up to 30%, designed to customer needs.
183	Web tool for logistic work-flow and event management.	Integration of logistical processes (transport, warehousing, customs), web-technology combined with workflow and event management.
184	-	-
185	Potato root harvester with bulk container.	New foliage separation technique, Large bulk container, open design, potato-friendly, easy maintenance.
186	Double twin shift, fertilizer tank unit.	Wheels can change track and width, Positive influence on soil structure.
187	Powerful microprocessor with 4Mb flash memory and secure micro controller.	Integration of 7 microchips in one SIM-card, enables remote and secure software downloads, Patented.

Appendix 5: Variables and survey items*

NEW PRODUCT OUTCOMES	
NPD Performance	
Succes01	The new product was launched on time.
Succes02	The new product has a high level of customer acceptance.
Succes03	The new product causes a high level of customer satisfaction.
Succes04	The new product delivers an excellent technical performance.
Succes05	The new product meets the quality goals.
Succes06	The new product attains profitability goals.
FinSuc07	**The new product attains unit sales goals.**
Succes08	The new product attains revenue goals (in Euro's).
FinSuc09	**The new product attains revenue growth goals.**
Succes10	The new product attains ROI goals.
Succes11	The new product attains margin goals.
FinSuc12	**The new product attains market share goals.**
FinSuc13	**The new product attains sufficient sales as a percentage of total company sales.**
TimSuc14	**The new product stayed under the development budget.**
TimSuc15	**The new product had a short 'time-to-market'.**
Succes16	The new product had a short 'break-even' time.
Product Advantage	
	According to customers…
Pradv01	the product offered a better technical performance than competing products.
Pradv02	**the product had a higher quality than competing products.**
Pradv03	the product was more user-friendly than competing products.
Pradv04	the product had a nicer design than competing products.
Pradv05	the product offered more value for its money than competing products.
Pradv06	the product solved a problem they had with competing products.
Pradv07	**the product was more innovative than competing products.**
Pradv08	the product reduced customer's costs.
Pradv09	**the product offered benefits that were not found in competing products.**
Pradv10	**the product was superior to competing products.**

MARKET INFORMATION PROCESSING VARIABLES	
Use of Market Information	
	In the stage predevelopment/development/commercialization….
Use1	market information was used in making decisions about the new product.
Use2	**market information was used in evaluating the new product.**
Use3	**market information had an influence on product-related decisions.**
Use4	different decisions would have been taken without market information.

Use5	**market information was used in solving project-related problems.**
Use6	market information was taken into account in decisions about the new product.
Use7	market information was used to improve the new product.
Use8	**market information was used to segment the market for the new product.**

Dissemination of Market Information

	During the NPD project…
Dissem1	a lot of informal 'hall talk' concerned our competitors' tactics or strategies.
Dissem2	we had interdepartmental meetings to discuss market trends and developments.
Dissem3	**employees spent time discussing customers' future needs.**
Dissem4	**documents circulated periodically that provided information on our customers.**
Dissem5	**in a short period everybody knew about it, when something important happened to a major customer or market.**
Dissem6	**data on customer satisfaction were disseminated at all levels on a regular basis.**
Dissem7	there was a lot of communication between project members concerning market developments.
Dissem8	Project members informed each other, when they had important market information.

Acquisition of Market Information

	During the NPD project…
Gather01	we regularly met potential customers to find out their future needs.
AcqCus02	**project members met potential customers to learn how to serve them.**
AcqCus03	**a lot of market research was done.**
AcqCus04	**we were quick in detecting changes in our customers' product preferences.**
AcqCus05	**we polled endusers several times to assess the quality of our product.**
AcqEnv06	**we often talked with those who could influence our endusers purchases.**
Gather07	we collected information about the market through informal means (e.g. talks with trade partners).
AcqEnv08	**intelligence on our competitors was generated by different departments.**
AcqEnv09	**we were quick in detecting fundamental shifts in our industry.**
AcqEnv10	**we periodically reviewed the likely effect of changes in our business environment on customers.**

PROJECT URGENCY CHARACTERISTICS

Project Priority

Prior1	**Priority was given to the project over other projects.**
Prior2	**Management considered the project more important than other running projects.**
Prior3	**The project's success was of utmost importance to our company.**
Prior4	Enough money was made available to complete the project successfully.
Prior5	**The project had a high status for our company.**

Time Pressure

	During the NPD project…
Timepr1	**employees often wished they had more time to complete their work.**
Timepr2	employees had plenty of time to think carefully about project-related details.
Timepr3	**employees believed they were under a lot of time pressure.**
Timepr4	**meeting deadlines was every time a difficult task.**

COMPANY STRUCTURAL CHARACTERISTICS

Formalization

Formal1	I feel that I am my own boss in most matters. **
Formal2	Employees here can make their own decisions without checking with anybody else. **
Formal3	**How things are done around here is left up to the person doing the work. ****
Formal4	**Employees here are allowed to do almost as they please. ****
Formal5	**Most employees here make there own rules on the job. ****
Formal6	Employees here are being checked on for rule violations.
Formal7	Employees here feel as though they are being watched to see that they obey the rules.

Centralization

Central1	There can be little action taken here until a supervisor approves a decision.
Central2	A person who wants to make his own decision would be quickly discouraged here.
Central3	**Small matters have to be referred to someone higher up for a final answer.**
Central4	**I have to ask my boss before I do almost anything.**
Central5	**Any decision I make has to have my boss' approval.**

Interdepartmental Conflict

	In our business unit…
Depart1	**employees feel that the goals of different departments are in harmony with each other. ****
Depart2	**protecting one's department turf is considered to be a way of life.**
Depart3	**there is little or no interdepartmental conflict. ****
Depart4	there is ample opportunity for informal 'hall talk' among individuals from different departments. **
Depart5	**different departments cooperate effectively to achieve mutual goals. ****
Depart6	**there is little or no tension among employees from different departments. ****

COMPANY CULTURAL CHARACTERISTICS

Cultural Market Orientation

ImpleMo01	**Our business objectives are driven primarily by customer satisfaction.**
ImpleMo02	**We constantly monitor our level of orientation to customers.**
Markor03	We inform all business functions about our successful and unsuccessful customer experiences.
ImpleMo04	**Our strategy for competitive advantage is based on our understanding of customer needs.**
MeasMo05	**We measure customer satisfaction systematically and frequently.**

MeasMo06	**We have regular measures of customer service.**
Markor07	We are more customer focused than our competitors.
Markor08	I believe that our business exists primarily to serve customers.
MeasMo09	**We poll end users at least once a year to assess the quality of our products and services.**
MeasMo10	**Data on customer satisfaction are disseminated at all levels in this business unit on a regular basis.**

Entrepreneurial Orientation

Enterpr1	We value creative new solutions more than the solutions of conventional wisdom.
Enterpr2	Top managers here encourage the development of innovative marketing strategies.
Enterpr3	We value a structured management process more highly than leadership initiatives for change. **
Enterpr4	Top managers in this business unit like to 'play it safe'. **
Enterpr5	Top managers around here like to implement plans only if they are very certain that they will work. **
Enterpr6	We firmly believe that a change in market creates a positive opportunity for us.
Enterpr7	People here tend to talk more about opportunities rather than problems.

R&D Dominance

	In our business unit…
Resdom1	**we have a lot of technical employees.**
Resdom2	**the majority of our managers has a technical background.**
Resdom3	**top management mainly consists of technical people.**
Resdom4	**technical employees have more influence on decisions than marketing employees.**
Resdom5	technical employees have a higher status than marketing employees.

Willingness to Cannibalize / Flexibility to New Products

	Our business unit…
Canibal1	can easily change its organizational scheme to fit the needs of a new product.
Canibal2	**supports projects even if they could potentially take away from sales of existing products.**
Canibal3	**easily replaces one set of abilities with a different set of abilities to adopt a new technology.**
Canibal4	**will pursue a new technology, even if it causes existing investments to lose value. ****
Canibal5	we find it difficult to change established procedures to cater to the needs of a new product. **
Canibal6	tend to oppose new technologies that cause our manufacturing facilities to become obsolete. **
Canibal7	are willing to sacrifice sales of existing products in order to improve sales of our new products.
Canibal8	can easily change the manner in which we carry out tasks to fit the needs of a new product.

* **Bolded** items remain in the final scales after EFA's and CFA's
** indicates a reversed item

Curriculum Vitae

Erik Veldhuizen was born in Dordrecht on April 23, 1976. He studied Business Economics at the Erasmus University of Rotterdam, and received his master's degree in September 1999, after an internship and graduation project at the Fraunhofer Institute in Stuttgart, Germany. In January 2000, Erik started his Ph.D. research at the Faculty of Industrial Design Engineering at the Delft University of Technology on the antecedents and consequences of market information processing in high-tech NPD.

In 2003, he was the runner-up winner of the Christer Karlsson Best Paper Award during the International Product Development Management Conference organized by the European Institute for the Advancement of Studies in Management (EIASM). In 2005 he was a winner of the 14th annual Business Marketing Doctoral Support Award Competition from the Institute for the Study of Business Markets (ISBM). His work was presented at several international conferences such as the European Marketing Academy (EMAC), and the research forum of the Product Development and Management Association (PDMA), and his research has been published in the *Journal of Engineering and Technology Management*.

Between 2004 and 2006 Erik developed and taught the course 'New product Economics' in the Master in Strategic Product Design at the Faculty of Industrial Design Engineering. In May 2006, he continued his career as a researcher for the National Accounts at Statistics Netherlands.