Decision making effectiveness in NPD gates

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By

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Abstract
Decision making effectiveness at gates is defined as the proficiency with which NPD managers use predefined performance criteria and assess usefulness of information generated by NPD activities when determining likelihood of new product success over the NPD process. This paper holds the general proposition that effectiveness of gate decision processes is contingent on NPD managers’ experience and NPD competences. It is analyzed how managers’ NPD experience and NPD competences moderate the influence of decision criteria and of information usefulness on new product reviews at gates. The identification of managers’ decision making behavior at gates provides ground for a discussion of challenges and opportunities for the establishment of gate decision making effectiveness. An experiential simulation was applied as research method for the exploration of gate decision-making over the NPD process. 131 NPD decision-makers from international, R&D SBUs placed in Scandinavia participated. The innovative direction or the historic focus of innovation seems to trap decision criteria priority. Even experienced decision-makers are inexperienced users of decision criteria at NPD gates. In addition, NPD managers’ level of information competence is perhaps challenging the integration of information from NPD activities into gate decisions.
Introduction

New product development (NPD) gates are at the review level of the NPD decision making hierarchy (McCarthy, et al., 2006; Jespersen, 2008). NPD gate decisions are assessment processes of information generated by NPD activities in the development stage of pre-specified decision criteria and of new product likelihood of success in the market performed between the stages of the NPD process (Steffens, Martinsuo and Arto, 2007; Cooper, 2008; Schmidt, Sarangee and Montoya, 2009). The core of the decision making process at gates is NPD managers. NPD managers make the prioritizations and decisions when the situation changes and problems/challenges occur in the NPD process (Day, 1994; Yadav, Prabhu and Chandy, 2007). The expectation of NPD managers is to base new product reviews on evaluations of decision criteria and assessments of information from NPD activities. This would be the rational decision making process of managers to follow at gates as this process ensures effective NPD decisions for the organization (Dean and Sharfman, 1996). In other words, decision making effectiveness at gates is contingent on NPD managers.

The reliance on NPD managers to behave rationally at gates gives rise to a relevant concern regarding the decision making effectiveness at gates. Behavioral decision literature has established that individuals have bounded rationalities influencing their capabilities (Simon, 1947). Empirical studies on decision criteria usage at NPD gates have determined the type of decision criteria applied at NPD gates (Hart, et al., 2003; Carbonell, Escudero and Aleman, 2004; Antioco, Moenaert and Lindgreen, 2008). Yet in these studies, the decision criteria usage is found to vary over the NPD process. Specifically, the design gate has been found to hold the lowest usage and the largest disagreement among the empirical findings (Antioco, Moenaert and Lindgreen, 2008). Furthermore, empirical studies of decision criteria usage show that intuition is a highly frequent criterion used by NPD managers at gates (Hart, et al., 2003). Research on the issue of escalating commitment at gates
The need to self-justify or to prove the rationality of an earlier decision interferes with economic decision rationally for new products (Bateman, 1986; Schmidt and Calantone, 2002; Biyalogorsky, Boulding and Staelin, 2006; Wong, Kwong and Ng, 2008). Other studies have found that NPD gate decisions are disconnected from NPD stages and strategic levels of NPD (Jespersen, 2008). In general, NPD gates are found by research and practice to be the weakest elements of the NPD process in innovation management. Research and managerial agreement state that “as go the gates as goes the process” (Cooper, 2008). As such it is likely that NPD managers’ characteristics influence the decision making effectiveness at gates.

Two characteristics of decision-makers that have been linked to decision making effectiveness are expertise and individual processing strategies (March, 1991; Salas, Rosen and DiazGanados, 2010). Expertise is defined as experience with in a domain that is assumed to result in a deep and rich knowledge base (Kaplan, Reneau and Whitecotton, 2001; Arnold, et al., 2004; Dane and Pratt, 2007; Berryman, 2008). For individual information processing strategies, the NPD competence exploitation/exploration continuum directs managers’ focus either to existing (exploitation) or to new (exploration) innovation knowledge, skills, and processes (March, 1991; Atuahene-Gima, 2005). NPD managers’ characteristics have not received attention in empirical studies of NPD gate decision making. The attention paid to NPD managers has concentrated on them as responsible parties for misbehavior at gates (Cooper, 2008). Focus has been on managers’ functional background (Krishnan and Ulrich, 2001; Antioco, Moenaert and Lindgreen, 2008) and recently on managers’ personality traits in relation to new product portfolio management decisions (McNally, et al., 2009). This is significant as the innovator’s dilemma has been readdressed in the light of managers’ capabilities (Henderson, 2006).

The purpose of this study is to extend research on NPD decision making by addressing the interdependencies of NPD managers and NPD gates over the NPD process. The investigated
research question is whether the characteristics of NPD managers influence decision making effectiveness at NPD gates. Specifically it is analyzed how managers’ NPD experience and NPD competences moderate the influence of decision criteria and of information usefulness on new product reviews at gates. The identification of managers’ decision making behavior at gates provides ground for a discussion of challenges and opportunities for the establishment of gate decision making effectiveness.

Over the course of the NPD process external movements in the market potentially affect the selection of the NPD gate decision process. Decision-makers face equivocality and uncertainty at different levels and adapt their NPD decisions in order to stay flexible and alert to the often changing market conditions (Williams, 1992; Koufteros, Vonderembse and Doll, 2002). Research on market information processing and innovation finds that information search and innovation effort are enhanced by changes in market conditions (Marinova, 2004; Siguaw, Simpson and Enz, 2006). Decision making research finds that environmental changes influence decision making effectiveness (Salas, Rosen and DiazGanados, 2010). Marinova (2004) argues that managers’ perception of changes in customer preferences and/or movement among their competitors influence judgment of decision input and performed decision outcome. Therefore, exploration of decision making effectiveness at NPD gates controls for an influence of changes in market conditions.

The present study of decision making effectiveness is a contribution to three strings of innovation research. First, the study contributes to the field of NPD gate decision making. Empirical studies have proven the existence of five overall performance criteria categories against which new products are judged at gates in the new product development process. These categories are technical, financial, strategic, customer and market-related criteria (Tidd and Bodley, 2002; Hart, et al., 2003; Carbonell, Escudero and Aleman, 2004). Decision criteria usage at NPD gates have determined the type of decision criteria applied at NPD gates (Hart, et al., 2003; Carbonell,
Escudero and Aleman, 2004). In addition, research has determined decision criteria frequency of use (Schmidt, Sarangee and Montoya, 2009), decision criteria importance (Carbonell, Escudero and Aleman, 2004), the influence of decision criteria dimensions on new product performance across gates (Carbonell-Foulquié, Munuera-Alemán and Rodríguez-Escudero, 2004), and decision criteria proficiency in gate decision making (Schmidt, Sarangee and Montoya, 2009). Further, review decisions at NPD gates in the development process are studied at an aggregated level through mortality curves. These depict how new product ideas survive over the course of the NPD process (Barczak, Griffin and Kahn, 2009; Schmidt, Sarangee and Montoya, 2009). This study examines the direct influence of decision criteria on gate reviews which to our knowledge has not been analyzed in previous studies. We aim to fill a part of this gap in extant literature through this study.

Second, market knowledge dimensions have been determined as significant for the integration of market knowledge into the NPD process to ensure high performing new products (De Luca and Atuahene-Gima, 2007). Similarly, the use of market information in various stages and its contribution to product advantage and/or market success is established (Veldhuizen, Hultink and Griffin, 2006). Yet, research also finds that companies vary in their sophistication regarding the integration of information sources into the NPD process (Zahay, Griffin and Fredericks, 2004). Further, the noise and signals that accompany information are factors that lead companies to employ conservative information bases of decision making (Leenders and Voermans, 2007). At the individual level of analysis perceived usefulness of information is found to be a condition for information use in decision making (Menon and Varadarajan, 1992). Perceived information usefulness is addressed as important for knowledge dissemination in cross-functional NPD teams (Moenaeart and Souder, 1996). Though performed NPD activities deliver information to be used at gate decision-making, the influence of perceived information usefulness of this received
information has not previously been investigated. We aim to address this gap and hope to extend information usefulness theory to the context of NPD decision-making.

Third, research on decision making effectiveness proves that the characteristics of decision-makers influence decision input and decision outcomes (Schmidt and Calantone, 2002; Salas, Rosen and DiazGanados, 2010). When investigating decision aid reliance, decision maker experience is also a significant determinant of decision-outcomes (Kaplan, Reneau and Whitecotton, 2001; Arnold, et al., 2004). This role of decision maker experience has not received attention in empirical studies of NPD gate decision-making. In the context of NPD gates, the attention paid to decision-makers has concentrated on them as responsible parties for misbehavior at gates (Cooper, 2008). Focus has been on the functional background of the decision maker (Krishnan and Ulrich, 2001; Antioco, Moenaert and Lindgreen, 2008) and recently on decision maker personality traits in relation to new product portfolio management decisions (McNally, et al., 2009). To our knowledge, the moderating effect of managerial characteristics on gate decision processes has not been investigated by previous research. By treating NPD managers’ experience and competences as moderating variables, this paper finds differences among NPD managers in decision criteria usage and decision making effectiveness. This paper thereby fills a gap in extant NPD gate literature.

To accomplish this contribution and to explore the phenomenon of stage-to-stage information dependencies of NPD, we conducted a quasi field experiment in a simulation of NPD gate decision making across five generic stages (idea, concept, design, test and launch). To address the primary research question of stage-to-stage information dependency, a controlled setting is required that allows for the explicit capture, over the span of the NPD process, of NPD managers and their selection of NPD activities for NPD decision-making. Since gate decisions are dynamic in nature, this research requires repeated measures of the selection of NPD activities over the span of the NPD process. This requirement precludes a cross-sectional survey method. A research method found
useful for studying the effects of informational and organizational variables on decision making is experiential simulations (simulation games or participatory simulations) (Guyot and Honiden, 2006; Harrison, Carroll and Carley, 2007). The participants are NPD practitioners who have NPD decision making responsibilities in their respective companies. The sample consists of large international companies whose NPD units are located in Denmark. Research has confirmed the similarities of NPD practices between Scandinavian and US companies (Kleinschmidt, 1994; Souder and Jenssen, 1999). The Danish origin of data is therefore not regarded as a bias in the paper’s discussion and comparison of results with NPD literature in general.

The paper is organized as follows. First, the relevant literature is reviewed and the hypotheses are developed. Thereafter follows a description of the modeled experiential simulation of NPD gates, sample characteristics and generated data. After a presentation of results, these are discussed, and conclusions are given along with managerial implications.

**Literature review and hypothesis development**

Decision making effectiveness at gates is defined as the proficiency with which NPD managers use predefined performance criteria and assess usefulness of information generated by NPD activities when determining likelihood of new product success over the NPD process (Schmidt, Sarangee and Montoya, 2009). Such proficiency by NPD managers at gates ensures that control is maintained over NPD projects (Riel and Lievens, 2004). The underlying assumption is that the assessment of the likelihood of new product success is a function of information usefulness and applied decision criteria (Dean and Sharfman, 1996; Cooper, 2008). This paper holds the general proposition that effectiveness of gate decision processes is contingent on NPD managers’ experience and NPD competences. The moderating effect of decision maker characteristics has been forwarded by
previous studies of information use (Moorman, Deshpande and Zaltman, 1992) and new product
decisions (Riel and Lievens, 2004; Kunc and Morecroft, 2010).

Figure 1 depicts the conceptual model analyzed in this paper. The model is a discrete system
with a recursive process (Klabbers, 2006). Gate decisions are influenced directly by perceived
information usefulness and decision criteria weights as well as previous gate decisions (the
recursive element of the system). The hypotheses in the model for both direct and moderating
effects on new product decisions are developed in the following.

> Insert figure 1 here <<

The antithesis of decision making effectiveness

The antithesis of decision making effectiveness at NPD gates is the positive reinforcement of new
product reviews from gate-to-gate (Schmidt and Calantone, 2002). Irrespective of the objective
potential in the market of a new product, research has proven that managers stay by new product
projects throughout the NPD process (Biayalogorsky, Boulding and Staelin, 2006; Kunc and
Morecroft, 2010). Innovation management literature refers to the phenomena as the escalation of
commitment to a new product regardless of prior expectations being right or wrong (Schmidt and
Calantone, 2002; Wong, Kwong and Ng, 2008). The driver of positive reinforcement over the NPD
process is a need for self-justification or to prove the rationality of an earlier decision which can
infer with economic rationality (Greve, 2008). Striving for self-justification makes NPD managers
more risk averse which results in an accumulation of additional resources to a new product project
(Kunc and Morecroft, 2010). In addition, research states that projects are rarely killed once passed
gate 1 (idea gscreen). In this respect, the innovation process resembles a tunnel more than a funnel
(Schmidt and Calantone, 2002; Cooper, 2008). Furthermore, the literature on escalation of
commitment finds that project completion increases NPD managers’ commitment to project continuation (Harvey and Victoriavich, 2009). Based on these research findings, NPD managers performing gate reviews for a new product through the NPD process can be expected to show cognitive favoritism that positively influences perceived likelihood in the market. Hence, it is hypothesized that:

Hypothesis 1: Prior gate reviews have a positive influence on current new product reviews.

**Proficient use of decision criteria at gates**

One control mechanism of decision making effectiveness at gates is the managers’ use of predefined decision criteria (Hart, et al., 2003; Schmidt, Sarangee and Montoya, 2009). The role of decision criteria at gates is to ensure equal assessments of NPD projects in the organization and to ensure proper resource deployment to NPD projects in the organization (McCarthy, et al., 2006; Sethi and Iqbal, 2008). Research has build knowledge on decision criteria mechanisms at gates through studies of the number of decision criteria at gates (Ronkainen, 1985; Hart, et al., 2003; Carbonell-Foulquié, Munuera-Alemán and Rodríguez-Escudero, 2004; Tzokas, Hultink and Hart, 2004) and studies of decision criteria importance for new product success (Carbonell, Escudero and Aleman, 2004; Schmidt, Sarangee and Montoya, 2009).

In addition to the above knowledge building on decision criteria mechanisms at gates, research has provided significant empirical results that form more precise expectations about proficient use of decision criteria that increase decision making effectiveness at gates (Ronkainen, 1985; Hart, et al., 2003; Carbonell-Foulquié, Munuera-Alemán and Rodríguez-Escudero, 2004; Tzokas, Hultink and Hart, 2004; Schmidt, Sarangee and Montoya, 2009). These empirical findings show that for the front-end gates, encompassing idea and concept stages, decision criteria with the
highest use are related to the market, to technical decisions and to strategic considerations. In the gates following the design development and testing stages the most frequently applied decision criteria are related to customers, to technical decisions and to financial concerns. Toward launch the empirical studies find that customer and financial related decision criteria are the most frequently used in the gate decision process (Ronkainen, 1985; Hart, et al., 2003; Carbonell-Foulquié, Munuera-Alemán and Rodríguez-Escudero, 2004; Tzokas, Hultink and Hart, 2004). Further, the decision dimensions related to technical criteria (Hart, et al., 2003) and market criteria (Carbonell, Escudero and Aleman, 2004) were also showing high use frequencies for the go-to-launch gate. Based on the above empirical findings, it is hypothesized that decision making effectiveness at gates increases if it is true that:

Hypothesis 2a: Decision criteria related to the market, to technical decisions and to strategic considerations have high influence on new product reviews in front-end gates.

Hypothesis 2b: Decision criteria related to customers, to technical decisions and to financial concerns have high influence on new product reviews in development and test gates.

Hypothesis 2c: Decision criteria related to customers and/or financial concerns have high influence on new product reviews in the launch gate.

*Proficient assessment information usefulness*

For each gate of the NPD process, NPD managers perform an assessment of information delivered from NPD activities performed in the related NPD stage (Cooper, 2008; Sethi and Iqbal, 2008). Information utilization research defines information assessments as perceived information usefulness of information searched for decision making (Deshpande and Zaltman, 1982; Wilton and
Myers, 1986; Deshpande and Zaltman, 1987; Moenaert and Souder, 1996; Biergelen, Ruyter and Wetzels, 2001; Arnold, et al., 2004; Sethi and Iqbal, 2008). The importance of perceived information usefulness for information use in decision-making, e.g., in gate decisions, is documented by research. Information utilization research finds that perceived information usefulness is a necessary and, at times, sufficient condition for information use (Menon and Varadarajan, 1992). The more positive the assessed usefulness of information, the more influential the information is on manager decision making (Song, van der Bij and Weggeman, 2005). This relationship is not a tautology as NPD managers exhibit different information valuation capabilities in the NPD process (Zahay, Griffin and Fredericks, 2004). This argument is supported by research which investigates the ability of decision-makers to integrate various information sources into the NPD process. Decision-makers find it difficult to act on collected information (Haas and Hansen, 2005). In other words, effective decision making at gates increases when information usefulness has a positive influence on new product reviews. Hence, it is hypothesized that:

Hypothesis 3: Increasing perceptions of information usefulness has a positive influence on gate reviews by NPD managers.

**NPD experience moderating gate decision making effectiveness**

Experience represents managers’ level of domain specific knowledge on which behavioral responses to given decision making situations are based (Salas, Rosen and Diaz-Ganados, 2010). In literature on decision making, the general thesis is that the duration of experience increases the depth and richness of managers’ knowledge bases in fields such as NPD (Ashill and Jobber, 1999; Arnold, et al., 2006). Experienced (NPD) managers hold a higher level of domain specific knowledge and are, as such, found more likely to process decisions against a background of prior
knowledge (Lipshitz, et al., 2001; Riel and Lievens, 2004; Salas, Rosen and DiazGanados, 2010). In a case study of the mobile telecommunication industry in the European Community, managers stressed that experience and developed understanding were significant for the effectiveness of their service innovation decisions (Riel and Lievens, 2004).

The problem which arises when relying on experience and intuition in decision making is that reliance on intuition reduces openness towards new solutions and processes (Salas, Rosen and DiazGanados, 2010). A decision maker with much experience may become too comfortable with prior choices (ossified), lose touch with user mindset, and/or be overconfident (Dane, 2008). Intuition is found to foster negative perceptions attached to evaluations at decision points (Ashill and Jobber, 1999). Marketing and innovation theories find that a ‘know-better’ attitude results in a negative relation between experience and judgment (Menon and Varadarajan, 1992), and that a negative attitude is associated with technically dominated orientations with an inward focus (Day, 1999). As such, it is reasonable to expect that predefined decision criteria and perceived information usefulness are more likely disregarded by experienced NPD managers for new product reviews at gates thereby potentially decreasing decision making effectiveness at gates. Empirical studies of decision criteria usage have shown that intuition is the most frequently used decision criteria at the idea and concept screening gates (Hart, et al., 2003). Thus, it is hypothesized:

Hypothesis 4: The influence of decision criteria weights on new product reviews are moderated negatively by NPD experience.

Hypothesis 5: The influence of information usefulness on new product reviews is moderated negatively by NPD experience.
To understand the moderating effect of NPD competence exploitation/exploration on decision making effectiveness at gates, it is useful to identify the underlying focus of decision criteria dimensions and information usefulness on innovation knowledge.

The focus on innovation knowledge by the five decision criteria dimensions (technical, financial, strategic, customer and market related) has been determined by NPD research and empirical studies of decision criteria at NPD gates (Hart, et al., 2003; Carbonell, Escudero and Aleman, 2004; Schmidt, Sarangee and Montoya, 2009). Performance criteria related to technical decisions and/or financial concerns utilize decision-makers’ existing innovation knowledge (Ahn, Lee and Lee, 2006; Greve, 2008). Strategic performance criteria may embrace both existing and new innovation knowledge as this behavior emphasizes leverage of current strategy ((Atuahene-Gima, 2005). The external orientation of customer and/or market criteria builds on market orientation theory and, as such, on new innovation knowledge (Hart, et al., 2003). Research on market orientation and innovation builds on the premises that market orientation increases the generation, dissemination and use of external information sources to gain insights on market and customers (Kohli and Jaworski, 1990; Narver and Slater, 1990). Thus, technical and finance decision criteria seem oriented toward NPD competence exploitation. In a similar vein, decision criteria related to strategic considerations, to customers, and to the market seem more likely fitted with NPD competence exploration. Hence, it is hypothesized that:

Hypothesis 6a: The influence of financial and technical decision criteria weights on gate reviews is moderated positively by NPD competence exploitation.

Hypothesis 6b: The influence of market, customer and strategic decision criteria weights on gate reviews is moderated positively by NPD competence exploration.
The relations of information usefulness and NPD competence leveraging are rooted in information familiarity of the NPD manager (Kaplan, Renaeu and Whitecotton, 2001; De Luca and Atuahene-Gima, 2007). Research shows that information from familiar information sources, i.e., NPD activities, has high influence on managers’ NPD decisions (De Luca and Atuahene-Gima, 2007). Through use and reuse of information sources, decision-makers become more capable of understanding information from repeatedly used NPD activities. They also become better equipped to transform information input from these familiar NPD activities into relevant knowledge for new product development (Zahra and George, 2002; Todorava and Durisin, 2007).

Unfamiliar NPD activities are those not previously used by NPD managers in NPD. One example of such activities is user-involving NPD activities (see Dahan and Hauser, 2002; Jespersen and Buck, 2009). The implementation of open innovation is still in its beginning which makes user-involving NPD activities new to most NPD managers (Chesbrough and Appelyard, 2007; Jespersen, 2010). Yet NPD activity unfamiliarity varies among NPD managers. Best practice studies have demonstrated that the type of NPD activity familiarity varies between managers (Barczak, Griffin and Kahn, 2009). The implementation challenge of unfamiliar NPD activities is that new innovation knowledge is difficult to use due to its more heterogeneous elements (De Luca and Atuahene-Gima, 2007). Though the knowledge pool is enriched, it demands a highly developed information capability to respond correctly to new information (Danneels, 2002; Katila and Ahuja, 2002). The heterogeneity of information input can lead to the mistaken impression by decision-makers that the NPD process is open again. This negative cost-benefit analysis of information input leads decision-makers to make a more negative product review at gates. In addition, the familiarity of NPD activities is likely to trap NPD managers and make them less sensitive to information input from new types of NPD activities (Leonard-Barton, 1992). In other words, it seems likely that assessed information usefulness is positively related to NPD competence exploitation and
negatively related to NPD competence exploration due to the concept of NPD activity familiarity. Thus:

Hypothesis 7a: The influence of information usefulness on gate reviews is moderated positively by NPD competence exploitation.

Hypothesis 7b: The influence of information usefulness on gate reviews is moderated negatively by NPD competence exploration.

Method

To address the primary research question of stage-to-stage information dependency in the NPD process, a controlled setting is required that allows for the explicit capture of NPD managers and their selection of NPD activities for NPD gate decision-making. Since gate decisions are dynamic and recursive in nature, research of NPD gates at the individual level of analysis requires repeated measures of choices and decisions over the span of the NPD process. This precludes a cross-sectional survey method. A research method found useful for studying the effects of informational and individual variables on decision making is experiential simulations (alias simulation games or participatory simulations) (Guyot and Honiden, 2006; Harrison, Carroll and Carley, 2007). Experiential simulations provide a stimulated environment of informational inputs in which people’s use of procedures, processes and decision rules can be observed, i.e., people demonstrate behaviors and decisions. An experiential simulation makes it possible to explore decision making as a series of events over time (Grant and Wall, 2009). Simulation modeling has been used for prediction of hypotheses, for proof and discovery of behavioral processes, as a means to explain
observed behavior, for assessment of pre-existing explanations, for prescription and for empirical guidance (Harrison, Carroll and Carley, 2007). The involvement of people in experiential simulations provides the opportunity for empirical research. The repeated use of MARKSTRAT for research proves the suitability of experiential simulation for research purposes (Marinova, 2004). In the following, our developed experiential simulation of NPD gate decision-making, NPDGATES, is accounted for in detail.

NPDGATES

The purpose of the NPDGATES simulation was to explain observed behavior at NPD gates through assessment of pre-existing assumptions of information search and information use for NPD decision-making. The simulation model of NPDGATES focuses on the individual decision making by NPD managers. It is a micro-level tool that specifies information flows as well as individual decisions and aggregates these decisions at the macro-level of the NPD process. NPDGATES simulates a formal, cross-functional process reported to be the norm in companies (Barczak, Griffin and Kahn, 2009). As the participants entered the simulation and began the decision making process for the new product in the simulation, the NPD gate decision making was observed for each of the five generic stages in the simulated NPD process (idea, concept, design, test, and launch) (Hultink, et al., 2000). The gate decision-points of the NPD process in NPDGATES contain three problem solving activities for decision-makers. The three activities are the selection of NPD activities, decision criteria priority, and new product decisions (Krishnan and Ulrich, 2001; McCarthy, et al., 2006; Jespersen, 2008). The new product developed in NPDGATES is a consumer good with a medium level of innovativeness. The technological aspect of the new product is novel within the industry but builds on an established technology in related industries. The product adds ease of use and flexibility for buyers without violating the traditional concept. Yet the applied technological
intelligence in the new product version expands the current frames of the core concept. The steps of NPDGATES are shown in figure 2 together with the role play designs and the interaction protocols (Guyot and Honiden, 2006).

After log-in, the participant filled in a questionnaire framed as a job interview. The questionnaire aimed at capturing relevant aspects of each decision-maker’s NPD experience and information competence as well as the innovation practices of the participant’s organization. After this ‘interview’ the participant was hired as a new NPD manager in the simulation company and led to the homepage of the simulation company where information on market conditions, the company’s NPD framework, NPD strategy, company situation and job expectations were available. The purpose was to create a virtual company for participating NPD managers to relate to and be motivated by. Hereafter followed the fuzzy front-end process of how the idea came about in the company. The story of the new product idea and its origin was unfolded. The actual development of the product idea then began following the steps in figure 2 for each of the five stages. At the end of the simulation, participants were encouraged to evaluate the simulation through a short set of questions and a comment box for additional inputs. In the following the interaction effectors controlled by participants are presented so as to account for how decision making behavior at gates was generated.

>> insert figure 2 <<

**NPDGATES model validation**

An experiential simulation mimics a constrained and simplified reality. Compared to theoretical and empirical knowledge on NPD gates and NPD decision-making, the modeled constraints are necessary simplifications of the simulation model. The simplification aptly preserves
comprehensibility and generalizability of the simulation results (Guyot and Honiden, 2006). NPDGATES had three constrained dimensions of the NPD process. First, the decisions about product requirements, the feedback loops and team-member actions as well as input on project progression are given in NPDGATES. Second, the NPD process is constrained to be sequential, because focus is on the various gate-points in the process. Third, the set of NPD activities to select from is limited to six for each stage, thirty in all, for the simulation model. We find that these simulation model constraints of NPDGATES increase the generalizability of results as the change of context across runs of the simulation is minimized (Lant and Montgomery, 1992). Yet the modeled constraints ensure that special attention is given to methodological reliability and validity.

For simulation design and use, there are three critical aspects to address: participant motivation, judgment bias and external validity (Feinstein and Cannon, 2002; Ramanath and Gilbert, 2004; Klabbers, 2006). *Participant motivation* includes a good structure, organization and a certain degree of formality of activities to perform in the simulation. The simulation was beta-tested on a group of NPD managers to ensure realism of all elements in the simulated environment. Following their test of the simulation, the beta-group managers were interviewed about the NPD activities developed for the simulation in order to determine suitability and realism as well as understandability of their information content. Based on the inputs from the beta-test, the content of the NPD activities in NPDGATES was adjusted. Further, motivation is maintained with good time-management and user-friendly software. Throughout NPDGATES, participants could see their progress and position in the simulation at a history panel on the left side of the screen. NPDGATES was anchored on a web-platform allowing the flexibility necessary to engage NPD managers in the study. NPD managers participated by logging in on an Internet site. The web-enabled design secured user-friendliness and flexibility with a 24/7 access to NPDGATES.
Judgment bias can have a substantial effect on a simulation model’s effectiveness. Research defines three categories of judgment bias: Bias related to data, to respondents and to decision maker use of data (Feinstein and Cannon, 2002; Ramanathan and Gilbert, 2004). Aspects within each of these have been addressed in the design of NPDGATES. First, data related bias was sought minimized by modeling NPDGATES to include open innovation NPD activities and thus avoid conservatism. Data saturation was sought minimized through short but rich information from the selected NPD activities and NPD stage descriptions. Second, bias related to respondents includes issues such as desire for self-fulfilling prophecies, expectations, habits and wishful thinking. To lower the bias from self-fulfilling prophecies, we sought in NPDGATES to built positive and negative elements into all presented information including the information content of the NPD activities. Hence, pros and cons were given on technical and market issues throughout the NPD process. The aim was to challenge any potential prophecies held by decision-makers. On the account of decision maker expectations, we sought to form these to match the simulated new product project by a comprehensive NPD context description. Specifically, the description of the NPD process was identical to the process participants were to meet in the simulation including a full list of potential NPD activities historically applied in the simulation company. This list matched the 30 NPD activities included in NPDGATES. To avoid information search habits in the NPD activity selection, the NPD activities were not stated by their method but by their purpose, e.g., ‘concept testing by focus groups’ was titled ‘concept evaluation by potential users’. This was the approach for all 30 NPD activities. Further, review decisions were measured as a two-item construct of evaluation and judgment to encourage decision consideration rather than decision automation or wishful thinking of go at all stages. Third, with concern for data presentation context, we mixed presentations of text, tables, graphs and pictures to minimize bias through a single presentation form. Also, samples characteristics such as industry, functional background, product newness and
technological newness were tested against perceived information usefulness, decision criteria weights and go-decisions with MANOVA models without finding significant relations.

*External validity* asks whether the internal functions of the simulation model correspond to relevant phenomena in a real world system (Feinstein and Cannon, 2002). For comparison of NPDGATES and real-world gates, we chose the approach of docking NPDGATES findings on NPD activity selection, information usefulness and decision criteria against literature findings. The perceived usefulness of received information was analyzed for NPD activity bias through ANOVA analysis revealing independency between NPD activities and perceived usefulness. This result is in congruence with previous studies of information usefulness arguing that the central aspect is acquisition purpose and real use of information (Wilton and Myers, 1986; Menon and Wilcox, 1994). An analysis of the distribution of decision criteria weights showed that technical and financial criteria are given higher priority than market criteria at all gates. This finding is in congruence with previous studies (Hart, et al., 2003; Tzokas, Hultink and Hart, 2004). We find that these efforts pertaining to stakeholder motivation, judgment bias and external validity support NPDGATES as a simulation modeling NPD gates in a real-world manner usable for research effort of NPD gate decision making throughout the NPD process. The data generated with the simulation is accounted for in the following.

Data generated by NPDGATES

*Modeled market conditions*

A recently developed perspective, albeit at a macro level, of the NPD context external to the organization emphasizes the competitive pressure facing companies. Focus is on how product development cycle time is reduced to beat competitors without compromising or missing out on
information (Carneiro, 2000; Flint, 2002; Griffin, 2002; Koufteros, Vonderembse and Doll, 2002; Lukas, Menon and Bell, 2002). Therefore, in this study, market condition changes refer to changes in competitor behavior. NPDGATES uses three models of market condition changes. In model 1, market conditions did not change relative to those described initially in the simulation. In model 2, market condition changes were modeled as a rumor about a major competitor launching a product similar to the one under development (step 1). This rumor was confirmed to illustrate that competitors acted as anticipated (step 2). In model 3, step 1 was repeated, but in step 2 the rumor was not confirmed so as to model unanticipated competitor movement. Market condition changes appeared at the idea and design stages of the simulated process. These two stages were chosen because the idea stage represents the front-end where participants perform up-front homework. Likewise in the design stage most development costs of a new product are committed.

To ensure randomness of market conditions experienced by participating NPD managers, the log-in was coded to assign model 1(n=48), model 2(n= 43) and model 3(n=40) in this order as participants initiated NPDGATES. For analysis, the dataset was split based on the modeled market condition changes experienced by participants.

*NPD managerial characteristics*

NPD managers’ innovation management experience was measured as seniority on a five point scale (1 = 0-2 year; 2 = 3-5 years; 3 = 6-10 years; 4 = 11-15 years and 5 = 15 years and above) related to both NPD and project management in general. In order to increase measurement accuracy, years were chosen over the corresponding measure of 1 = none and 5 = very high. Also, research states that expertise requires a ten year period in a domain (Dane and Pratt, 2007).

NPD managers’ experience with NPD competence development was measured as exploration and exploitation according to Atuahene-Gima (2005). The respondents were asked to place a
“curser” on a continuum going from high disagreement to high agreement with an underlying interval scale from 1 to 100. The performed factor analyses yielded .682 Cronbach alpha for NPD competence exploitation and .605 Cronbach alpha for NPD competence exploration.

Perceived information usefulness

NPDGATES holds six NPD activities in each stage of the simulated NPD process. The NPD activities were included in NPDGATES on the basis of innovation management research (Henard and Szymanski, 2001; Dahan and Hauser, 2002; Crawford and Di Benedetto, 2008). Table 1 lists the 30 NPD activities in NPDGATES. Participants were asked in each stage to judge the importance of the NPD activities at hand and to select those they would like to receive information from. It should be noted that the NPD activity selection was performed within the constraints of an NPD activity budget. The purpose of the budget was to make the NPD activity selection a conscious choice (Hogarth, 1987; Bettman, Payne and Johnson, 1993). The budget level in NPDGATES was determined through company interviews. The price (resources/cost) of each NPD activity was based on details given in interviews with market research companies in Denmark. We also took into account the genuine comprehension of explorative activities as more resource demanding than exploitative activities (March, 1991). A concern was that the budget in the simulation influenced participant’s selection of NPD activities. Either participants were thought not to notice the budget and therefore spend it in the first stages, or they were thought to select NPD activities at the end of the simulation in order to use their full budget. We tested these two scenarios by analyzing correlations and mean differences in the amount spent in each NPD stage, the number of NPD activities selected in each stage and total budget spent. These tests were not significant thereby confirming the selection of NPD activities as a conscious, realistic choice made by participants.
Perceived usefulness of information is participants’ assessment of the selected NPD activities in each stage of NPDGATES. Ex-post the reception of information from the selected NPD activities, participants were asked: “How would you characterize the usefulness of the set of information that you just received?” (Biergelen, Ru yter and Wetzels, 2001). The applied scale was a graphic smiley scale with an underlying measure of usefulness from 0 to 100 (0 = very unhappy; 25 = unhappy; 50 = neither/nor; 75 = happy; 100 = very happy). NPD managers were to move a cursor in the right position on the scale to state their perceived usefulness.

>> insert table 1 here <<

**Decision criteria priority**

The decision criteria in NPDGATES followed the five dimensions identified in NPD literature: technical, strategic, customer related, financial, and market. Each dimension was exemplified with criteria in accordance with the literature on the topic (Hart, et al., 2003; Carbonell, Escudero and Aleman, 2004), e.g., customer related decision criteria were customer satisfaction and product quality. For each of the gates in the simulation, participants were asked to allocate 100 points among the five categories according to their relative importance for the go-decision (Carbonell, Escudero and Aleman, 2004).

**New product reviews**

The review decisions at gates were measured using a two-dimensional construct of likelihood of success on the market (Schmidt, Montoya-Weiss and Massey, 2001) and go or stop of the project. The NPD decision-makers were asked to evaluate the new product’s likelihood of success on the
market at the time on a scale from 0 to 100 (evaluation). Afterwards, they were asked whether they would recommend go or stop (binary variables).

Sample

In the data collection process initial contact was established by phone to potential participants. Upon acceptance of participation an email was sent containing a description of the study, a webpage link and log-in information. The sample consisted of large international companies whose NPD units were located in Denmark. The sample was drawn from the national register of business in Denmark. Targeted industries included food, textile, electronics, machinery, industrial carpentry, and information technology. The selection criteria of the targeted companies were reasonable size, consumer products and NPD in Denmark. Participants were invited to participate because they were their companies’ NPD gatekeepers. They were identified through organizational charts and company interviews. Data was collected in the fall of 2007. All potential participants were pre-notified and then sent a personal log-in code to the simulation home-page. Preliminary notification by phone was used to solicit cooperation, check the relevance of the study for the identified person, and increase the number of participants. Of 600 contacted NPD managers 189 participated and of these 131 completed the entire simulation. As an incentive and a way to indicate the relevance of the study to participants, participants were asked to indicate whether they wanted to receive a report of the preliminary research findings from the simulation. Over 96% did. The sample characteristics are displayed in table 2. To evaluate the extent of possible bias, the participants were tested across groups for differences in their behavior caused by industry, functional background (e.g marketing, engineering, IT, R&D), and early vs. late participation. These tests were insignificant. Sample characteristics were not found to create bias in simulation behavior.
Further, the three market condition models in NPDGATES were tested for sample difference in the independent, moderating and dependent variables with ANOVA analysis. Theses analyses did not find significant differences in averages of model variables across the three modeled market conditions.

>> insert table 2 <<

Analysis
In table 3 the mean weights given to decision criteria over the NPD process in NPDGATES is shown. The bold numbers highlight decision criteria given highest weights on average in each gate. Mean differences in decision criteria weights, perceived information usefulness and assessed likelihood of success across the three market conditions models in NPDGATES were tested with ANOVA analysis. The ANOVA analysis did not show significant differences and as such table 3 shows total sample means. Table 3 shows that decision criteria related to technical decisions, financial concerns and customers are given higher priority than decision criteria related to the market and strategic considerations at all gates. This finding is in congruence with previous studies (Hart, et al., 2003; Tzokas, Hultink and Hart, 2004). Differences in managerial characteristics were also tested with ANOVA analysis of mean differences across market condition models. These tests did not show significant results. NPD experience and NPD competences are not skewed in the market condition models of NPDGATES.

>> insert table 3 <<

The iterative nature of gate decisions processes and the interdependence of gates over the NPD process statistically mean that the gate decision process is a system of interdependent linear
equations. The descriptors of the system may be both manifest and latent variables which are likely
to cause overfitting of dimensions to y (assessment of likelihood of success in the market). The
multicollinearity of decision criteria weights given by respondents is especially high in the gate
decision process. In this case the solution of classical least squares problem does not exist or is
unstable and unreliable. Another method found useful to handle overfitting and multicollinearity is
partial least squares (PLS) regression. (Hulland, 1999). Though PLS-regression is a path modeling
technique among latent variables, it may also be applied for one-component, latent variables
(Trygg, 2002). In other words, PLS-regression holds the strength of leading to a stable model based
on simultaneous OLS regression analyses even for highly correlated descriptor variables. Because
NPD gates are full systems of information inputs, decision criteria judgment and new product
decisions (Cooper, 2008), data generated with NPDGATES were analyzed through use of PLS-
regression for one-component variables. Another advantage of PLS regression is the use
bootstrapping in PLS algorithms which makes PLS-regressions especially suitable for small
samples as typically generated with experiential design. In this study, PLS was performed with use
of the program SmartPLS (Ringle, Wende and Will, 2005). The PLS-regressions were carried out
for each of the three market model conditions in NPDGATES. The regression results are shown in
tables 4 and 5.

>> insert table 4 and 5 <<
Results

The general proposition of the paper was that new product reviews at gates would be influenced by NPD managers’ characteristics. The results show that current gate decisions are influenced by prior decisions. The antithesis of decision making effectiveness is true across gates and market conditions (see table 4). Hypothesis 1 is confirmed. The NPD process acts more as a tunnel than a funnel (Cooper, 2008). Optimistic or pessimistic expectations may lead to overestimation or underestimation by NPD managers (Kunc and Morecroft, 2010). The human factor of self-attribution is unavoidable (Mullins and Sutherland, 1998; Schmidt and Calantone, 2002; Greve, 2008). NPD gates have to account for these at all stages. Yet prior decisions are not trapping entirely NPD managers in their decision making. Managers’ escalating commitment at gates can be reduced. The results presented below (table 4 and 5) provide insights into the mechanism of NPD gates and give knowledge about how to enhance decision making effectiveness at gates.

Proficient use of decision criteria at gates

The results in table 4 demonstrate proficient use of decision criteria at gates by NPD managers as hypothesized in hypothesis 2a-c. Market, technical and strategic decision criteria influence new product reviews at gate 1 and gate 2. Hypothesis 2a is accepted. In gate 3 and 4 following design and test stages of the NPD process, customer, technical and financial decision criteria are found to influence new product reviews in gate 3. This is less so in gate 4. Hypothesis 2b is partly supported. In gate 5, it was hypothesized that customer and financial decision criteria demonstrate higher influence on new product reviews. Table 4 confirms this expectation (hypothesis 2c is accepted).
A formed expectation of gate effectiveness was that decision criteria dimensions given high weights by NPD managers would influence new product reviews at gates. Therefore, it is interesting to relate the average weights in table 3 to the PLS-regressions in table 4. According to table 3 (bold numbers), technical, financial and customer related criteria should influence new product reviews whereas strategic and market related decision criteria should not. These weights in table 3 are in contrast to the results in table 4 where strategic and market decision criteria have a significant direct influence on new product reviews by NPD managers across gates. This difference may indicate a discrepancy between organizational decision criteria and NPD decision criteria caused by differences in market orientation levels. A higher level of market orientation in NPD is an expected consequence of research focus on market orientation in NPD literature during the last decades (Hart, et al., 2003).

The cognitive characteristics of NPD managers were expected to moderate NPD managers’ decision effectiveness at gates. Experience was hypothesized to moderate negatively the influence of decision criteria on new product reviews based on the notion that experience would increase NPD managers’ use of intuition at gates thereby lowering decision making effectiveness. The results in table 4 show that experience moderates negatively the proficient use of strategic and financial related criteria at gates across the NPD process and market condition models (hypothesis 4 is partly supported). It is reasonable to expect that NPD experience increases NPD managers’ knowledge on strategy and finance in company NPD. These two dimensions are not in the same state of flux as technical, customer and market related decision dimensions are. It is therefore more likely that experienced managers use intuition on strategic and financial dimensions (Salas, Rosen and DiazGanados, 2010).

With regard to NPD managers’ competence characteristics, competence exploitation was hypothesized to moderate positively the influence of finance and technical related decision criteria
on new product reviews. The results in table 5 partly support hypothesis 6a as there is a positive moderating effect of exploitation on financial related decision criteria. In table 5, the positive moderation of NPD competence exploration on strategic, market and customer related decision criteria is confirmed (hypothesis 6b is accepted). For market related decision criteria the positive moderation of exploration occurs in the first gates of the NPD process. Also it should be noted that competence exploitation moderates positively customer and market related decision criteria. One explanation is that NPDGATES includes open innovation activities which are new to NPD managers. In this early phase of open innovation adaptation, NPD managers may use competence exploitation to learn from their NPD competence exploration. NPD literature has defined exploitation as a necessary partner facilitating exploration (Katila and Ahuja, 2002; Gupta, Smith and Shalley, 2006). A risk is that NPD managers will be trapped by their competence exploitation (Leonard-Barton, 1992; Atuahene-Gima, 2005; Ahn, Lee and Lee, 2006; Wang and Li, 2008). This is supported by the negative moderating effects of competence exploration on market decision criteria at gate 3 ($\beta_{G3; M1} = -.6876; \beta_{G3; M2} = -.4656$), gate 4 ($\beta_{G4; M1} = -.5096; \beta_{G4; M2} = -.6689$) and gate 5 ($\beta_{G5; M1} = -.2601$) as well as the insignificant effects in high turbulent environments (model 3) where competence exploitation moderates market decision criteria positively ($\beta_{G2; M3} = .4452; \beta_{G4; M3} = .8176; \beta_{G5; M3} = .2797$).

*Information usefulness and gate decisions*

New product reviews at gates were expected to be positively influenced by assessed usefulness of information delivered from NPD activities over the NPD process (hypothesis 3). The PLS-regression results in table 4 confirm this proposed relationship conditioned on NPD managers experiencing anticipated market condition changes ($\beta_{G1; M2} = .7164; \beta_{G2; M2} = .2877; \beta_{G4; M2} = .4512;$
β_{G5;M2} = .5624). For stable (model 1) and unanticipated markets (model 3), information usefulness does not influence new product reviews. NPD managers rely on intuition when uncertainty is not resolved by reassurance from competitors (the market). This is interesting since average perceived information usefulness does not vary across market conditions in NPDGATES (table 3). In congruence with information usefulness research (Menon and Varadarajan, 1992; Song, van der Bij and Weggeman, 2005), information usefulness as perceived by NPD managers is found to influence new product reviews. Further, we add knowledge to this line of research by showing that market condition changes influence NPD managers’ use of intuition in NPD gate decision making. We return to this in the discussion.

Experience was expected to increase NPD managers’ use of intuition in decision making thereby decreasing the influence of information usefulness on new product reviews (hypothesis 5). The results in table 4 do not show significant moderating effects of NPD experience on information usefulness (hypothesis 5 in not accepted). As experience is not moderating information usefulness, there is a risk of inexperienced NPD managers making immature judgments (Salas, Rosen and Diaz-Ganados, 2010).

For NPD managers’ competence exploitation and/or exploration the central issue was information familiarity (Kaplan, Reneau and Whitecotton, 2001; De Luca and Atuahene-Gima, 2007). Table 5 confirms the positive moderation of competence exploitation conditioned on NPD managers operating in stable markets (β_{G1;M1} = .6957; β_{G3;M1} = .6996; β_{G5;M1} = 2.410). As such, hypothesis 7a is accepted. The moderating effect of competence exploration is found to be predominantly positive as anticipated. Hypothesis 7b is not accepted. Yet it is interesting that under high uncertainty (model 3) NPD managers characterized by competence exploration can competently transform collected information into decisions (β_{G1;M3} = 1.5494; β_{G3;M3} = .4557; β_{G5;M3} = 1.2290). Research concurs with the positive use of NPD competence exploitation in certain
markets (model 1) and of NPD competence exploration in uncertain markets (model 3) (Gupta, Smith and Shalley, 2006; Wang and Li, 2008).

Because perceived information usefulness could cover any range of NPD activities, it was explored whether any particular NPD activity selected in the simulation was driving perceived information usefulness in each stage. Correlation analysis (Spearman) and regression analysis on the relation between NPD activity selection and perceived information usefulness did not provide significant results. Companies are found to vary in their sophistication regarding the integration of information sources into the NPD process (Zahay, Griffin and Fredericks, 2004). Research variously denotes the information environment as a window of opportunity (Foray, 2004) and a window of entrapment (Slater and Mohr, 2006). The raised concern is that it is not known whether performed NPD activities frame an information opportunity or entrapment. NPD managers seem satisfied with information from performed NPD activities. Yet research asserts that decision-makers are trapped by information familiarity and therefore less sensitive to detailed input from other information sources (Leonard-Barton, 1992; De Luca and Atuahene-Gima, 2007). On this basis, perceived usefulness of information depends on NPD managers’ information competence.

**Discussion and conclusion**

In the NPD process, it is widely agreed upon that NPD gate decisions are essential for new product outcomes. However, there is equal concurrence that NPD gates are the weakest link of NPD processes in companies. The purpose of the paper was to investigate the mechanisms of decision making effectiveness at gates. The innovative direction or the historic focus of innovation seems to trap decision criteria priority. Even experienced decision-makers are inexperienced users of decision criteria at NPD gates. In addition, NPD managers’ level of information competence is
perhaps challenging the integration of information from NPD activities into gate decisions. Furthermore, and in line with previous research, the results show that NPD gates are influenced by competitors’ behavior in the market environment (Marinova, 2004; Siguaw, Simpson and Enz, 2006; Lichtenthaler and Lichtenthaler, 2009).

The first finding emerging from our study is that the mechanisms of decision making effectiveness at gates vary with the market conditions faced by NPD managers. In stable markets (model 1) NPD managers apply internally oriented decision criteria matching the organizational decision focus. Customer decision criteria do not influence new product reviews, and market related criteria have a negative influence on these. NPD managers’ competence exploitation positively moderates information use thereby decreasing intuitive decision making at gates. If competitor movements in the market were anticipated (model 2), then NPD managers disregarded decision criteria in new product reviews, but applied information from NPD activities in the gate reviews. Further, experience and NPD competences did not moderate the decision making process. It seems that competitors´ reassurance makes NPD managers disregard own capabilities. Unanticipated competitor movements (model 3) make NPD managers apply externally oriented decision criteria (market, strategy and customer); especially from gate 3 and onward in the NPD process (table 4). NPD managers’ level of competence exploration increases decision making effectiveness at gates in volatile markets. These decision making mechanisms influencing decision making effectiveness at gates add to research fields on NPD gates and on competitors’ influence on NPD. The results show that decision making effectiveness increases with market uncertainty. This is significant as it could indicate entrapment of NPD efforts by NPD managers in companies (Ahuja and Lampert, 2001; Greve, 2008), the exception being companies operating in volatile markets such as high technology markets. This result is supported by NPD gate research (Schmidt, Sarangee and Montoya, 2009).
In relation to the entrapment of innovation efforts by NPD managers, we add to research by finding that there is a discrepancy between organizational and NPD decision criteria. The findings from NPDGATES show that technical and financial decision criteria state the innovative direction NPD managers must adhere to in organizations. The negative influence of market criteria on new product reviews in stable market conditions supports this ($\beta_{G2, M1} = -0.2740; \beta_{G3, M1} = -0.7149; \beta_{G4, M1} = -0.5757$). One explanation for the conflict can be that organizations have build up routines for technical and financial decision criteria that lead to a self-attribute of actions by NPD managers at gates (Greve, 2008). Research on core rigidities conceptualizes this behavior as entrapment of the innovative effort in organizations (Atuahene-Gima, 2005).

For core rigidities, NPD managers’ uses of exploitation or intuition at gates indicate a success trap of NPD gates. It is in stable market conditions (model 1) that NPD managers apply the highest number of decision criteria (3 or more) across gates. In model 2 where competitors reassure the new product project, the number of decision criteria influencing new product reviews is highest at gate 1 and 2. For model 3 in a market of high uncertainty, the number of decision criteria influencing new product reviews increases over the NPD process. The mechanisms of the success trap are that previous NPD processes and routines are replicated from one NPD project to another (March, 1991). Gate decision making is to follow rigorously a checklist (Sethi and Iqbal, 2008). It is likely that the success trap of NPD gates found in this study offers a potential explanation of the high decision criteria use frequency for incremental NPD projects relative to radical NPD projects found in previous empirical studies of NPD gates (Schmidt, Sarangee and Montoya, 2009). It is not uncertainty of incremental NPD that increases the amounts of decision criteria used, but rigorous replication of past innovation behavior. Differently under high uncertainty, NPD managers turn to the backbone of NPD success through demonstration of an external orientation. The presented
results support this together with previous research on exploration and NPD success (Gupta, Smith and Shalley, 2006). Therefore the number of decision criteria used in radical NPD projects is lower.

A second finding emerging from the results is that anticipated changes in market conditions act as reassurance of innovation effort. NPD managers disregard decision criteria and their NPD experience and competences. The reassurance of competitive imitations indicates a comfort zone for NPD managers in their NPD efforts (Marinova, 2004; Johnson, 2007; Sethi and Iqbal, 2008). Some researchers have argued for a contingency view, proposing that the comfort of competitors’ reassurance of the NPD efforts increase the cognitive freedom of NPD managers thereby activating the exploratory information search in the NPD process (Benner, 2009). The positive influence of information usefulness on gate reviews in model 2 supports this. It is interesting that the reduced stress on gates by reassurance of competitors gives NPD managers more cognitive room for rational models of information processing (Zack, 1999; Benner, 2009; Salas, Rosen and Diaz-Ganados, 2010). Yet the results indicate that information from NPD activities is perceived useful across all NPD activities in NPDGATES. Hence NPD managers do not differentiate between internal, external or open innovation activities. As perceived usefulness of information depends on NPD managers’ information competences (De Luca and Atuahene-Gima, 2007), it is likely that NPD managers hold a weak information competence. The information competence of NPD managers at gates may therefore cause the struggle with the implementation of tools and methods in the NPD process stages raised in research (Hauser, Tellis and Griffin, 2006). The results for information usefulness demonstrate that NPD managers have difficulties when transforming collected information into decisions (Haas and Hansen, 2005). Though at a macro-level, absorptive capacity research posits that the capability to transform and exploit collected information by incorporating it into the firm’s operations varies more between organizations than the capability to collect external information (Zahra and George, 2002).
Based on the above findings the paper concludes that decision making effectiveness at gates can be improved by attending to the mechanisms of the gate decision process. Current gate decision behavior of NPD managers potentially traps NPD effort in organizations.

**Managerial implications**

The present study holds three recommendations for NPD gate decision making that would contribute to higher decision making effectiveness benefiting NPD efforts in organizations. First, it is recommended that the application and use of decision criteria at NPD gates is assessed. The assessment of this should investigate two aspects. First, decision criteria use should match and follow the innovative direction and not vice versa. Decision criteria use should be strategically aligned. Second, decision criteria may vary from project to project due to different levels of project innovativeness, but they should not vary from NPD manager to NPD manager in the same organization. Such an assessment would help managers avoid managerial misbehavior at gates and ensure high decision making effectiveness.

Second, it was interesting to find that the information capability to transform information input into relevant information for NPD was untrained by decision-makers. Therefore, we recommend that decision-makers include information competence development in their work. This can be accomplished through formal, individual education, but should be extended to the organizational level as part of the resource optimization of NPD. Through information competence enhancement, the appreciation of NPD competence exploration is likely to increase in NPD gate decision-making. This would allow NPD managers to secure the innovativeness of new products and a higher performance on markets as ‘the needs of users’ are transferred into NPD decision-making. In the era of open innovation NPD managers need adequate information competences with
focus on user involvement in NPD. The need for formal training is supported by NPD research. The conferences of IPDM and PDMA host special tracks for teaching innovation management.

Third, an increase in the experience with open innovation information sources in NPD is recommended. Novice and experienced NPD managers are equally inexperienced with open innovation activities. This introduces the risk of immature judgments of new product projects by NPD managers. For this to provide positive returns of future NPD, it is important to let information source exploration facilitate this implementation. Of equal importance is it not to let information source exploitation hamper the information input from these sources.

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References


Figure 1. Conceptual framework
### Figure 2. The simulation model steps of NPDGATES

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Table 1. NPD activities modeled into NPDGATES

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Table 2. Sample characteristics

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<th>Characteristic</th>
<th>%</th>
<th>Characteristic</th>
<th>%</th>
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<td>New</td>
<td>41.22</td>
</tr>
</tbody>
</table>

Table 3. Descriptives (means) of the gate decision process elements

<table>
<thead>
<tr>
<th>Decision criteria</th>
<th>Gate 1</th>
<th>Gate 2</th>
<th>Gate 3</th>
<th>Gate 4</th>
<th>Gate 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer</td>
<td><strong>26.198</strong></td>
<td><strong>23.450</strong></td>
<td><strong>28.443</strong></td>
<td><strong>29.412</strong></td>
<td><strong>30.542</strong></td>
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<tr>
<td>Information usefulness</td>
<td>3.878</td>
<td>3.8626</td>
<td>3.901</td>
<td>4.275</td>
<td>4.282</td>
</tr>
<tr>
<td>New product reviews</td>
<td>.5011</td>
<td>.5163</td>
<td>.5635</td>
<td>.6239</td>
<td>.7133</td>
</tr>
</tbody>
</table>

The bold numbers illustrate the decision criteria dimensions given highest weight in the particular gate on average in NPDGATES.
### Table 4. Direct effects and moderating effects of NPD experience on new product reviews (y) at NPD gates (standardized coefficients)

<table>
<thead>
<tr>
<th></th>
<th>Gate 1</th>
<th>Gate 2</th>
<th>Gate 3</th>
<th>Gate 4</th>
<th>Gate 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M1*</td>
<td>M2</td>
<td>M3</td>
<td>M1</td>
<td>M2</td>
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<tr>
<td>Direct effects</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Technical</td>
<td>.6381***</td>
<td>-0.0355</td>
<td>-0.0521</td>
<td>-.1737</td>
<td>.3605**</td>
</tr>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Strategy</td>
<td>.3271*</td>
<td>-.6308**</td>
<td>.5344*</td>
<td>.0494</td>
<td>.6743**</td>
</tr>
<tr>
<td>Customer</td>
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<td>-.2871</td>
<td>-.0068</td>
<td>.0913</td>
<td>-.1128</td>
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<tr>
<td>Finance</td>
<td>.3472*</td>
<td>.3431*</td>
<td>.1611</td>
<td>.1359</td>
<td>.3956**</td>
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<tr>
<td>Market</td>
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<td>-.7496**</td>
<td>.4675**</td>
<td>-.2740*</td>
<td>.2898**</td>
</tr>
<tr>
<td>Information usefulness</td>
<td>.3177</td>
<td>.7164**</td>
<td>.9044**</td>
<td>.1999*</td>
<td>.2877**</td>
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<tr>
<td>Prior gate decisions</td>
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<td></td>
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<td>.6613***</td>
<td>.8134***</td>
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<td>Experience x ______</td>
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<td>.4951*</td>
<td>.2593*</td>
<td>.1318</td>
</tr>
<tr>
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<td>-.0347</td>
<td>-1.0346**</td>
<td>.0581</td>
<td>-.3054*</td>
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<td>-.1808</td>
<td>.7460*</td>
<td>.2923*</td>
<td>.5346**</td>
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<tr>
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<td>-.4756**</td>
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<td>-.2621*</td>
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<tr>
<td>Market</td>
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<td>.7519**</td>
<td>.1905</td>
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<td>.0458</td>
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<td>-.1655</td>
<td>.9044</td>
<td>-.6199**</td>
<td>-.2295</td>
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</tbody>
</table>

| R²                   | .6679                 | .6759                 | .7143                 | .8883                 | .8860                 | .8992                 | .8402                 | .7683                 | .9264                  | .8461                 | .8187                 | .9017                 | .8364                 | .8267                 | .8814               |

* M1 = no changes in market conditions; M2 = anticipated changes in market conditions; M3 = Unanticipated changes in market conditions.

** p < 0.001; *** p < 0.01; * p < 0.05; * p < 0.10
Table 5. Moderating effects of NPD competences on new product reviews (y) at NPD gates (standardized coefficients)

<table>
<thead>
<tr>
<th></th>
<th>Gate 1</th>
<th>Gate 2</th>
<th>Gate 3</th>
<th>Gate 4</th>
<th>Gate 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M1°</td>
<td>M2</td>
<td>M3</td>
<td>M1</td>
<td>M2</td>
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<tr>
<td>Exploitation</td>
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<tr>
<td>usefullness</td>
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<tr>
<td>Exploration</td>
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<td>Technical</td>
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<td>.2934*</td>
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<td>.5102**</td>
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<tr>
<td>usefullness</td>
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</tr>
</tbody>
</table>

R² | .6679 | .6759 | .7143 | .8883 | .8860 | .8992 | .8402 | .7683 | .9264 | .8461 | .8187 | .9017 | .8364 | .8267 | .8814 |

° M1 = no changes in market conditions; M2 = anticipated changes in market conditions; M3 = Unanticipated changes in market conditions
*** p < 0.001; ** p < 0.01; * p < 0.05; ° p < 0.10
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