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The impact of the fuzzy front end on new product development success in Japanese NPD projects

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In a study of Japanese New Product Development (NPD) projects, the fuzzy front end of innovation is explored. Our conceptual model is based on the information-processing perspective. A structual equation model was fitted to data from 497 NPD projects from Japanese mechanical and electrical engineering firms to test the proposed model.

The empirical analysis found support for all hypotheses except for one. Our study suggests that an early reduction of market and technical uncertainty and a draft initial planning prior to development have a positive impact on NPD project success. The model accounts for 17% of the variance of the efficiency and 24% of the variance of the effectiveness dependent variable. Thus, the front end phase is an important driver of NPD project success. Implications of the model are discussed.

1. Introduction

The fuzzy front end, a term first popularized by Smith and Reinertsen (1991), is considered to be the first stage of the NPD process and roughly is meant to range from the generation of an idea to either its approval for development or its termination (Murphy and Kumar 1997). Cooper (1988) divides the fuzzy front end into four phases from idea generation, initial screening, and preliminary evaluation to concept evaluation and stresses the importance of both market-related and technical activities. Khurana and Rosenthal (1998) define the front end to include product strategy formulation and communication, opportunity identification and assessment, idea generation, product definition, project planning, and executive reviews.

Several studies highlight the importance of the fuzzy front end (e.g., Atuahene-Gima, 1995; Booz, Allen Hamilton, 1982; Dwyer and Mellor, 1991 and Shenhar et al., 2002). Cooper and Kleinschmidt (1994: 26) found that "the greatest differences between winners and losers were found in the quality of pre-development activities". The fuzzy front end determines which projects will be executed. Quality, costs, and timings are mostly defined during the front end. At this early stage, the effort to optimize is low and effects on the whole innovation process are high (Smith and Reinertsen, 1991 and Verganti, 1999). Thus, a deeper understanding of the fuzzy front end and its impact on NPD sussess appears to be called for in order to help firms achieve greater success in their efforts to develop new products.

In literature, the fuzzy front end first appeared in association with research into success factors. The fuzzy front end was predominantly restricted to one factor, e.g. the "quality of pre-development activities" (Cooper and Kleinschmidt, 1990: 16). Although the number of publications related to the fuzzy front end has been increasing recently, most of them are thoretical approaches (Reid and Brentani, 2004; Zhang and Doll, 2001) or explorative studies (Khurana and Rosenthal, 1998; Rosenthal and Capper, 2006; Koen et al., 2001 and Montoya-Weiss and O'Driscoll, 2000). Reid and Brentani (2004) develop a theoretical model of the fuzzy front end information flow and decision-making process for discontinuous innovations. Their model focuses on the fuzzy front end and does not link it to latter phases or NPD success. Zhang and Doll (2001) develop a causal model of the fuzzy front end and NPD success. They emphasize the need to separate between front-end fuzziness and front-end activities. While the models of Reid and Brentani (2004) and Zhang and Doll (2001) are theoretical models, Langerak et al. (2004) test their proposed model with structural equation modeling. They use data from 126 firms in the Netherlands to investigate the structural relationship among market orientation, the proficiency in predevelopment activities, new product performance, and organizational performance. They focus on market-oriented firms and find partial support for the importance of market orientation and the proficiency in predevelopment acitivities. Considering the small number of empirical studies so far, it is not surprising that Kahn et al. (2003: 193) still see the fuzzy front end as an important future research direction for product development management.

Another suggestion by Kahn et al. (2003: 193) is to examine Japanese new product development approaches. In accordance with Song and Parry (1997b: 1), literature about Japanese NPD can be devided into four streams. The first stream describes NPD methods developed in Japan, e.g. Kaizen or Quality Function Deployment (QFD) (e.g., Cristiano et al., 2000). The second stream focuses on large, highly visible Japanese firms like Canon, Sony or Honda and is usually case-based (e.g., Clark and Fujimoto, 1990; Harryson, 1997 and Takeuchi and Nonaka, 1986). Empirical research about NPD practices in Japan is the third stream (Song and Parry, 1996, Song and Parry, 1997a). Further studies compare Japanese to Western NPD practices (Edgett et al. 1992 and Song and Parry, 1997b). Referring to the fuzzy front end, there is some evidence in literature that the fuzzy front end has a positive influence on the outcomes of Japanese NPD (Herstatt et al., 2006: 57; Nakata and Im, 2005: 280; Song and Parry, 1997a: 69 and Song and Parry, 1997b: 10). Herstatt et al. (2004) compare Japanese to German front-end practices and propose that Japanese companies rely on more formal approaches to reduce uncertainties during the fuzzy front end than German companies. Their findings are based on a small sample size of 14 NPD projects in each country.

Overall, a quantitative confirmatory study of the influence that the fuzzy front end has on NPD success in Japanese companies has yet to be published. The aim of this paper is to address this gap by building on the work of NPD and Technology and Innovation Management (TIM) scholars. In order to gain insight into the fuzzy front end, we suggest a conceptual model and test the proposed model with structural equation modeling.

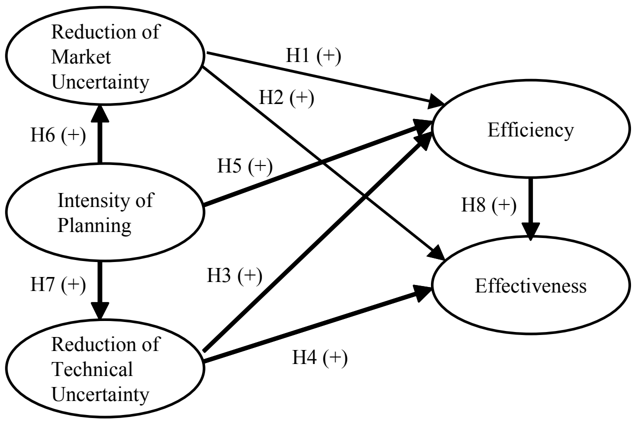
The paper is organized as follows. After this brief introduction (section 1), the concpetual model is derived in the next section. Section 3 gives more detailed insights into our hypotheses and measures. Section 4 and 5 describe our research methodology and analysis. In section 6, results are summarized. Section 7 discusses our empirical findings and outinlines managerial implications. We close with a discussion of research limitations and directions for future research.

2. Conceptual model

The definition and operationalization of the factors and the interrelationships are discussed in this section. We drew upon literature about success factors, the fuzzy front end and recent reviews of the literature for guidance in developing our conceptual model. The unit of analysis was the individual product development project.

In the NPD process, relevant information has to be gathered in order to reduce risks and uncertainties (Kim and Wilemon, 2002 and Moenaert et al., 1992). Galbraith (1973: 5) defines uncertainty as “the difference between the amount of information required to perform a particular task, and the amount of information already possessed by the organization”. The more that a risk or uncertainty can be reduced during the front end of this process, the lower the deviations from front end specifications, during the subsequent project execution phases and hence, the higher the product development success. This information-processing or uncertainty reduction perspective was also applied by Lievens and Moenaert (2000: 47), Sherman et al. (2005: 401) and Song et al. (2005: 432). According to Lynn and Akgun (1998), uncertainties inherent in NPD projects relate to the market and technology. Based on the information-processing view that we adopted on new product development, we linked the level of uncertainty reduction during the fuzzy front end to new product development success (Clark and Fujimoto, 1991 and Souder and Moenaert, 1992).

The hypothesized relationships between the model factors are graphically represented in Figure 1.



Source: own depiction.

Figure 1. Hypothesized relations between fuzzy front end factors and NPD project success.

3. Hypotheses and measures

The model poses three key front end factors that determine NPD projects’ effectiveness and efficiency. Based on the assumptions of Zhang and Doll (2001: 97), we separate between front-end fuzziness and front-end activities and focus on the latter which can be influenced by management. The three front end factors of our model are ‘Reduction of market uncertainty’, ‘Reduction of technical uncertainty’, and ‘Intensity of (initial) planning’ prior to development.

The factors of our research were operationalized according to approaches recommended by Peter (1979) and Jarvis et al. (2003). Through an intensive literature analysis and the development of the comceptual framework, we specified the domain of the factors and generated a sample of items that could be used for measurement purposes. To create the factors, we relied on existing operationalizations in the literature. For each factor, follwing the decision rules of Jarvis et al. (2003: 203), we verified if the assumed direction of causality – from the latent variable to its measures – is appropriate.

The reduction of market uncertainty should lead to a more in-depth understanding of the market. The factor 'Reduction of market uncertainty' in our model refered to knowledge about customers' needs and wants, price sensitivity and market attractiveness prior to development. The items were selected from Song and Parry's constructs 'Marketing proficiency' (1997a: 74) and 'Proficiency in the business and market opportunity analysis stage' (1997b: 14), focussing on market-related items relevant for the fuzzy front end.

We used two factors for NPD success at the project level: 'Efficiency' and 'Effectiveness'. Success measures have been controversially discussed in literature (e.g., Ernst, 2001; Hauschildt 1991 and Pinto and Slevin, 1988a). Regarding the point of time at which the measurement takes place, we asked respondents to describe the development of the last product brought onto the market (last-incident method). To assess 'Efficiency', compliance with financial and personnel resources planned during the fuzzy front end was assessed by the respondents (Ernst, 2001; Dvir and Lechler, 2004 and Pinto and Slevin 1988a). Effectiveness asseses the project's outcome from the point of view of different stakeholders: meeting profit targets, customer satisfaction and competitive advantage achieved by the new product. We measured 'Effectiveness' by slightly modifying scales from the studies of Lynn et al. (2000: 228) and Pinto and Slevin (1988a).

Taking the empirical studies of Calantone et al. (1996), Cooper and Kleinschmidt (1987), Dwyer and Mellor (1991), Langerak et al. (2004), Lynn and Akgun (2001), Moenaert et al. (1995), Ottum and Moore (1997) and Song et al. (1996) as a starting point, we can propose a positive link between the reduction of market uncertainty and project success.

Hypothesis 1. The efficiency of new product development projects is positively affected by the degree of reduction of market uncertainty during the fuzzy front end.

Hypothesis 2. The effectiveness of new product development projects is positively affected by the degree of reduction of market uncertainty during the fuzzy front end.

The information-processing perspective was also applied to the measurement of technical uncertainty. Following Cooper and Kleinschmidt (1987: 185) and Song and Parry (1996: 429), the factor 'Reduction of technical uncertainty' refers to a well-understood technology, specification of technical requirements and anticipation of technical problems prior to development. Several studies indicate that early reduction of technical uncertainty has a strong influence on project success (Bstieler, 2005; Calantone et al., 1996; Cooper and Kleinschmidt 1986; Dvir et al., 2003; Dwyer and Mellor, 1991; Moenaert et al., 1995; Mishra et al., 1996 and Song and Parry, 1996). Taking these contributions into account, we could suggest a positive relationship between the reduction of technical uncertainty and project success.

Hypothesis 3. The efficiency of new product development projects is positively affected by the degree of reduction of technical uncertainty during the fuzzy front end.

Hypothesis 4. The effectiveness of new product development projects is positively affected by the degree of reduction of technical uncertainty during the fuzzy front end.

When the overall objective of a NPD project is clear, an initial planning prior to the start of development translates the overall project goals into a series of activities with a clear allocation of resources for each. Although some information may at that point in time be difficult to forecast, overall uncertainties are reduced by laying out a draft process from development to product launch. The first step of initial planning is to break the product development project down into various work packages. Thereafter, timescales, resources and overall responsibilities are allocated to each of the work packages (Cleland, 1999). The factor 'Intensity of (initial) planning' refers to the intensity of these activities prior to the start of development and is based on the factors 'Planning quality' and 'Proficiency of the predevelopment planning process' from Dvir and Lechler (2004: 11) and Song and Parry (1996: 430). Langerak et al. (2004: 208) use a similar factor they call 'Proficiency in strategic planning'. Numerous empirical studies of project success factors suggest planning as one of the major contributors to the success of projects (Balachandra and Friar, 1997; Cooper and Kleinschmidt, 1987; Dvir and Lechler, 2004; Langerak et al., 2004; Maidique and Zirger, 1984; Pinto and Slevin, 1988b; Shenhar et al., 2002; Souder, 1987 and Zirger and Maidique, 1990). Taking these results into account, we suggested the same relationship between initial planning and project efficiency.

Futhermore, an intensive initial planning brings together team members with different backrounds and from different functions to share information and understand different viewpoints (Thieme et al., 2003: 108). Thus, we expected an effective initial planning to support the gathering of information and therefore to reduce the degree of uncertainty about market and technology (Smith and Reinertsen, 1991: 82 and 181 and Thieme et al., 2003: 109). Based on the above-mentioned studies, Hypotheses 5, 6 and 7 propose a positive impact of an intensive initial planning on efficiency and the reduction of uncertainties.

Hypothesis 5. The efficiency of new product development projects is positively affected by the intensity of planning prior to the start of development.

Hypothesis 6. The dregree of reduction of market uncertainty during the fuzzy front end is positively affected by the intensity of planning prior to the start of development.

Hypothesis 7. The degree of reduction of technical uncertainty during the fuzzy front end is positively affected by the intensity of planning prior to the start of development.

In our study, we measure success with the two constructs 'Efficiency' and 'Effectiveness'. Several empirical studies show a strong correlation between project efficiency and project effectiveness and/or different aspects of project effectiveness (Dvir and Lechler, 2004; Lipovetsky et al., 1997; Maidique and Zirger, 1984 and Rubenstein et al., 1976). Thus we propose:

Hypothesis 8. The effectiveness of new product development projects is positively affected by NPD efficiency.

4. Research method

4.1 Data collection procedure

The factors obtained from literature and exploratory interviews were verified during a pilot study and a pre-test. As items had to be translated into Japanese, in particular the interpretation of the questions was verified. The purpose of the pilot study and the pre-test was (a) to assess construct validity and further purify the scales if necessary and (b) to evaluate and improve the quality of the questionnaire prior to full implementation of the survey. The results suggested that several scales reported in former studies could be used with minor modifications. A few additional items resulting from the interviews were added to the constructs.

The proposed model was examined using the revised standardized questionnaire which was sent to 2000 research and development directors of mechanical and electrical engineering companies identified in Japan. The database from a Japanese industry association used to identify companies and R&D directors covers the majority of Japanese companies (census assumed). Out of the total of 2000 questionnaires, we achieved a response rate of 28%. Of these 555 questionnaires, 497 data sets could be used for analysis. Comparisons of average values did not identify significant differences between those questionnaires that were returned early and those that were returned later, so in accordance with Armstrong and Overton (1977), we did not assume a significant non-response bias. We used 7-point Likert-type scales ranging from 1 = *strongly disagree* to 7 = *strongly agree* and 1 = *objectives not achieved* to 7 = *objectives exceeded.*

4.2 Company and project characteristics

The size of the firms participating in our study ranged from having 5 to 70000 employees and annual sales ranging from 5 billion Yen to 30000000 billion Yen. For the purpose of this study, interviewees were asked to describe the development of the last product brought onto the market. This definition includes the modification of existing products. However, as shown in Figure 2, most of the new products studied here were medium or highly innovative. According to the scheme of Booz, Allen & Hamilton (1982: 9), 28% of the products were new to the world, 36% new product lines and 14% product modifications. Only 22% of the products had a rather low degree of newness (either repositioning in the market or cost reduction products). Thus, the NPD projects were relatively balanced concerning the degree of newness of new product concepts.

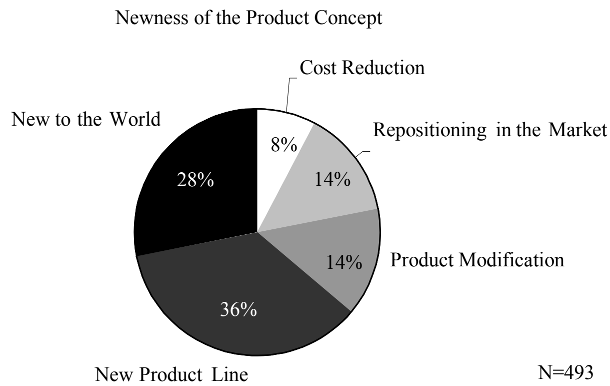


Figure 2. Degree of newness of the new product concepts to the firms.

5. Analysis

5.1 Measurement Validation

The reliability of each factor was assessed in the following manner. Firstly, traditional reliability measures were used. Items with a low item to factor loading were deleted and Cronbach alpha of each factor was calculated. This step led to a minor modifications of one factor. All factors showed sufficient reliability. Secondly, the factors were integrated into a measurement model and tested with AMOS. We followed the two-step approach recommended by Anderson and Gerbing (1988). First of all, the measurement model was estimated and thereafter the measurement model was estimated in conjunction with the structural model. Using the estimation results, the reliability of the whole measurement model and the reliability, and discriminant validity of factors and items were assessed. Table 1 summarises some of the lower limits used for measurement validation. With all but a few exceptions, requirements were fulfilled and therefore no further re-specifications were made. The results suggested that the measurement model adequately fits the data and that testing the structural model was appropriate.

Table 1. Limits for measurement validation.

Criterion	Limit
Whole model:	
GFI	≥0.9
AGFI	≥0.9
NFI	≥0.9
RFI	≥0.9
Measures:	
Indicator reliability	≥0.4
Factor reliability	≥0.6
Average variance for each factor	≥0.5

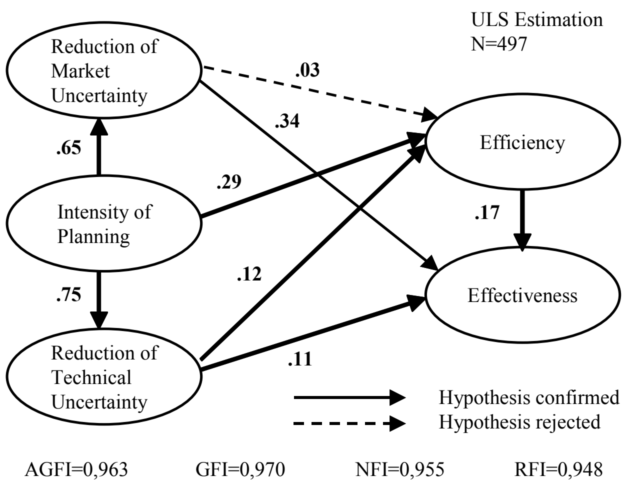
Source: Homburg and Baumgartner (1995).

5.2 Model testing and estimation

The results of the AMOS estimation are summarised in Figure 3. The fit indices AGFI, GFI, NFI, and RFI exceeded 0.9. Therefore, the overall fit of the model was satisfactory. Only one of the eight proposed relationships was rejected. This indicates a sufficient validity of the model. The appendix provides an overview of factors together with items comprising each factor, descriptive statistics, interconstruct correlations and the results of the reliability analysis. Results indicated that the reliability and discriminant validity of the measures were satisfactory, except for the factor 'Intensitiy of Initial Planning' with a factor reliability of 0.73 an three indicator reliabilities slightly below the limit of 0.4. Overall, the confirmatory analysis was successful and therefore results can be discussed in the next section.

6. Results

Figure 3 presents standardised path coefficient estimates for the proposed relationships of the conceptual model presented in Figure 1.



Source: own depiction.

Figure 3. Results of the structual equation model. Parameter estimates are from the completely standardized solution.

The proposed model was not rejected. Except for one hypothesis, relationships could not be rejected either. Table 2 summarizes the results for the hypotheses testing.

Table 2. Hypotheses testing results.

Hypothesis	Result
Hypothesis 1	Rejected
Hypothesis 2	Supported
Hypothesis 3	Supported
Hypothesis 4	Supported
Hypothesis 5	Supported
Hypothesis 6	Supported
Hypothesis 7	Supported
Hypothesis 8	Supported

The positive impact of the reduction of market uncertainty on project effectiveness supports hypothesis 2. Contrary to the predections, a positive impact on project efficiency as proposed by hypothesis 1 was not found. One reason for this result could be the selection of technical-oriented mechanical and electrical engineering companies. Many of these do not develop new products for the consumer market, they develop industry goods in close cooperation with their customers. Consequently, changing customer requirements during the NPD project play a minor role compared to consumer goods companies. Another explanation is provided by Bstieler (2005: 279) whose study delivered similar results: Bstieler assumes that the company of his study do not emphasize the execution of market-related activities for efficient development. Instead technical factors become more important when accelerating development and meeting cost targets is the objective.

In line with prior research, hypotheses 3 and 4 describing the positive effect of the reduction of technical uncertainty on project success are supported by the path coefficients.

The intensity of planning prior to the start of a project had the highest positive effect (+0.29) on efficiency (see hypothesis 5). The positive effects of the intensity of planning on the reduction of uncertainties during the fuzzy front end were the strongest direct effects resulting from our analysis with +0.65 for market uncertainty (Hypothesis 6) and +0.75 for technical uncertainty (Hypothesis 7).

Consistent with previous studies, the effectiveness of new product development projects is positively affected by NPD efficiency (+0.17) and hypothesis 8 could not be rejected.

Table 3 summarizes indirect and total effects of front end factors on NPD project success. The intensity of planning had a positive indirect effect on efficiency as well as on effectiveness and in sum the strongest positive effect on both.

Table 3. Indirect and total effects (standardized estimates).

	Path to:			
	Efficiency		Effectiveness	
Path from:	Indirect	Total	Indirect	Total
Reduction of market uncertainty				**0.34**
Reduction of technical uncertainty		**0.12**	0.02	**0.13**
Intensity of planning	0.09	**0.21**	0.37	**0.37**

Overall, the three front end factors – initial planning, reduction of market and technical uncertainty – accounted for 17% of the variance in the efficiency and 24% of the variance in the effectiveness dependent variable (squared multiple correlations).

As the only other large-scale study by Langerak et al. (2004) focuses on a different country (the Netherlands), market-oriented firms and products new to the firm, but familiar to the market, a comparison with our results is not appropriate. Nevertheless, taking the two studies together, the importance of the fuzzy front end finds empirical support for different countries and industry sectors.

7. Conclusions

Due to the short number of studies which show empirical support of the impact of the fuzzy front end on success, the purpose of this paper has been to provide theoretical and empirical evidence which allows us to confirm the fuzzy front end as an important future research direction. In our study, we assessed the impact of the fuzzy front end on new product development success in Japanese NPD projects. The fuzzy front end was examined from an information-processing perspective, that is, in terms of uncertainty reduction. Consistent with previous research, support was found for the contribution of uncertainty reduction during the fuzzy front end to the effiency and effectiveness of new product development projects. The key driver of project success was the intensity of planning prior to the start of development. Except for one, all of the proposed relationships between front end factors and project success were supported. The results summarized here comfirm the usefulness or our conceptual model in understanding the relationship between the fuzzy front end and NPD success.

The model accounted for 17% of the variance in the efficiency and 24% of the variance in the effectiveness dependent variable. Given that we focused on the fuzzy front end phase and neglected project execution, these values exceeded expectations.

Several implications can be drawn from our study:

(1) Product development effectiveness can be achieved by an early reduction of technical and market uncertainty supported by an intensive initial planning.
(2) Managers should early in the development process focus on the reduction of technical uncertainty and ensure a high quality initial planning when aiming for an efficient product development.
(3) An intensive initial planning reduces market and technical uncertainty during the fuzzy front end.

In addition, the fuzzy front end was confirmed as a future research direction that fulfills the criteria of Kahn and Franzak et al. (2003: 199): It is a topic considered by the academic as well as by the practitioner community and therefore has a high "leverage value" (Miller, 1998: 10; Reinertsen, 1999: 25 and Zhang and Doll, 2001: 95).

8. Limitations and future research

Although our study increases our understanding of the fuzzy front end of new product development, there are several limitations to this study. Our study suffers from limitations related to ex-post measurement, the choice of key informants and structural equation modeling which have already been extensively discussed in previous research (e.g., Calantone et al., 1996; Dvir and Lechler, 2004; Ernst, 2001 and George and Torger, 1982). Causality cannot be proven with structural equation modeling and therefore findings must be used with caution. In addition, the results should be interpreted with a possible bias related to the single-informant approach in mind.

Futhermore, we focused on two similar industry sectors in one country. Future research could for instance compare Japanese with Western NPD projects with regard to the fuzzy front end. Last but not least, we only considered the fuzzy front end and project success, neglecting the project execution between. This opens opportunities for further research exploring indirect effects in more depth by integrating factors representing the project execution phase.

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APPENDIX: MEASURES, RELIABILITY AND VALIDITY

Table 4. Interconstruct correlations.

	Red. of market uncertainty	Red. of technical uncertainty	Intensity of initial planning	Efficiency	Effectiveness
Red. of market uncertainty	1.00				
Red. of technical uncertainty	0.49	1.00			
Intensity of initial planning	0.65	0.75	1.00		
Efficiency	0.28	0.35	0.40	1.00	
Effectiveness	0.44	0.34	0.38	0.31	1.00

Data source:own calculation and illustration.

The Fornell/Larcker criteria is fulfilled for all factors.

Table 5. Measurement items and descriptive statistics.

Factor	Measurement items	Mean	SD
Efficiency	Planned personell resources were sufficient.	4.06	1.49
	The project had come in on budget.	3.94	1.41
Effectiveness	To what extent did the new product fulfill your company's objectives with regard to the following aspects?		
	▪ Profit?	4.61	1.56
	▪ Sales?	4.76	1.46
	▪ Market share?	4.84	1.44
	▪ Competitive advantage?	5.34	1.25
	▪ Customer satisfaction with the product?	5.38	1.05
Reduction of market uncertainty	We fully understood our potential customers' needs, wants and specifications for this product prior to development.	5.40	1.38
	Customer requirements were integrated into the definition of the new product concept.	5.33	1.31
	We knew well the size of our potential market for the new product prior to the start of development.	5.03	1.44
	We knew how much the customers would pay for such a product – his/her price sensitivity.	5.03	1.44
	We identified "appeal" characteristics that would differentiate and sell the product.	5.91	1.11
	We appraised competitors and their products – both exixting and potential.	5.72	1.31
Reduction of technical uncertainty	The product's specifications – exactly what the product should be – were very clear from the beginning.	4.92	1.48
	Technical requirements for the product were clearly specified prior to the start of development.	5.26	1.26
	Technical feasibility of the product concept was thoroughly verified prior to the start of development.	4.63	1.40
	The technical aspects – exactly how the technical problems would be solved – were very clear from the beginning.	4.66	1.40
	We knew well and understood the technology behind this product.	5.13	1.33
Intensity of initial planning	The entire project task (scope) was structured in work packages.	5.49	1.51
	Every work package was allocated with a specific time allowance.	4.27	1.54
	Resources (personell, financial) were assigned to the work packages.	4.43	1.41
	There was a detailed budget plan for the project.	4.21	1.55
	Team member responsibilities were defined.	5.06	1.53

Data source:own calculation and illustration.

All items were measured on a 7-point Likert-type scale.

Table 6. Measures and reliability.

Factor	Indicator (abbreviated)	Indicator reliability	Factor reliability	Average variance
Efficiency	Planned personnel resources	0.58	0.81	0.69
	On budget	0.79		
Effectiveness	Profit	0.61	0.88	0.59
	Sales	0.68		
	Market share	0.58		
	Competitive advantage	0.52		
	Customer satisfaction	0.56		
Reduction of market uncertainty	Customers' needs, wants and specifications	0.61	0.84	0.47
	Customer requirements	0.62		
	Size of potential market	0.50		
	Price sensitivity	0.36		
	"Appeal" characteristics	0.32		
	Competitors	0.38		
Reduction of technical uncertainty	Product specifications	0.47	0.85	0.53
	Technical requirements	0.51		
	Technical feasibility	0.62		
	Technical problems	0.52		
	Technology behind the product	0.51		
Intensity of initial planning	Work packages	0.34	0.73	0.36
	Time allowance	0.23		
	Resources	0.40		
	Budeget plan	0.37		
	Responsibilities	0.44		

Data source:own calculation and illustration.