Extended Model of Managing Risk in New Product Development Projects

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The aim of this research was to study new product development (NPD) projects-related risks and the literature in this field, as well as to develop a specific extended model of managing risks in NPD projects, which will consider the nature of NPD projects. Data were collected with the help of the developed questionnaire, and project managers with several years of experience in the field of NPD projects were included. The data and hypotheses were tested with the use of statistical methods. Results of the study show that for NPD projects, it seems to be crucial to plan risks in the early stages of the project, especially focused on the definition of the technical requirements for the product and the related clear project objectives. Poorly defined technical requirements for the product present an important risk related with the design uncertainty of the product. The more imprecise the technical requirements for the product before the project starts, the higher is the design uncertainty of the product after its development. Unclear project objectives have a significant effect on the time-delay of NPD projects. The more imprecisely the project objectives are defined before the project starts, the greater is the time-delay on the NPD project.

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Introduction

New product development (NPD) projects are often managed to achieve a faster time-to-market objective through a shorter iterative process (Ammar, Kayis, and Sataporn 2007). Many different approaches, such as concurrent engineering and team work are adopted to achieve that objective (Salamone 1995). This leads to achievement of the right design in the first attempt and helps attain clarity for the issues in the implementation phase of the project, resulting in overall lower development costs and quicker response to the market as compared to a traditional over-the-wall approach (Jo, Parasaei, and Sullivan 1993). The design pro-

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cess determines the product geometry, materials, functional specifications, machining processes, assembly sequences, tools, and equipment necessary to manufacture a product (Ammar, Kayis, and Sataporn 2007). Production plans and control tools, such as inventory controls, resource allocations and job scheduling, are other important outputs of the design process.

It can be detected that design influences to a great extent the quality and the cost of the product (Salmone 1995; Jo, Parasaei, and Sullivan 1993). Shortcomings in the product design process result in extra costs generated through project delays, penalties, an excess of materials used, labor, additional operations, resource relocations, additional planning, and re-scheduling. They are all related to different risks. Therefore, management of the risk has to be employed in all these stages of a project.

Several definitions of risk are available in the literature, as in the following examples. Risk management presents one of the main areas of the project management (Palčič et al. 2007). Risk management is a life-cycle process which covers the project from its definition to customer service. Risk focuses on the avoidance of loss from unexpected events (Williams 1995). Risk is usually referred to as an exposure to losses in a project (Webb 1994; Chapman and Ward 1997) or as a probability of losses in a project (Larson and Kusiak 1996; Remenyi and Heafield 1996; Taha 1997). While uncertainty is not measurable, it can be estimated through subjective assessment techniques (Raftery 1994). The risk management process refers to uncovering weaknesses in methods used in product development through a structured approach, so that timely treatment actions are initiated to avoid risk, transfer risk, reduce risk, or reduce risk impact (*Risk Management Standard* AS/NZS 4360 1999). It is an organized proactive process of identification, measurement and developing, selecting, and managing options for handling those risks (Kerzner 2004). The risk management process blends itself to product design and development, as changes and interactions in the design stage cost less than changes initiated in the implementation phase (Salamone 1995; Jo, Parasaei, and Sullivan 1993). Early discovery of risk events leading to downstream losses is much more preferable than treating losses when they cannot be prevented (Ammar, Kayis, and Sataporn 2007).

In the literature, different authors offer different approaches which help us to manage risk on the projects. An overview of some of the models is presented in table 1.

Tseng, Kyelleberg, and Lu (2003) have identified a four-stage risk ma-

TABLE 1 Overview – risk management as a several stage process by different authors

Author	Risk management process	Stages
Mulcahy (2003)	5-step risk management process	Risk management planning, risk identification, risk analysis, risk response planning, risk monitoring and control.
Raz and Michael (2001)	4-step risk management process	Identification, assessment, treatment, monitoring.
Chapman (1998; 2001)	9-step risk management process	Definition, strategic approach, identification, information structuring, ownership, uncertainty estimation, magnitude of risks, response, monitoring and controlling.
Klein and Cork (1998)	4-step risk management process	Identification, analysis, control, reporting.
Fairley (1994)	7-step risk management process	Identification, assessment, treatment, monitoring, contingency planning, managing the crisis, recovery from crisis.

nagement process; risk identification, analysis, response development and control (Tseng, Kyelleberg, and Lu 2003). Durofee uses a four-stage process to manage risk; risk identification, quantification, response development and control (Durofee et al. 1996). Klein and Cork have described risk management as a four-phase process: risk identification, analysis, control and reporting (Klein and Cork 1998). Boehm (Boehm 2001) suggested risk assessment (identification, analysis and prioritization) and risk control (risk management planning, risk solution and risk monitoring planning, tracking and corrective action). Chapman (Chapman 1998) proposed seven phases: definition, strategic approach, uncertainty estimation, magnitude of risks, response, monitoring and controlling. Fairley (Fairley 1994) proposed seven steps: identification, assessment, mitigation, monitoring, contingency planning, managing the crisis and recovery from the crisis.

Thus, risk management models are generally composed of four stages (Conroy and Soltan 1998; Raz and Michael 2001): risk identification, risk assessment, risk treatment and risk monitoring. Several risk types are included in every NPD project. These risks are also covered in project management literature (Chapman 2001; Kayis et al. 2003; Kusumo et al. 2003; Zhou et al. 2002). Also Stare (2004) defines the risk management process as a five-stage process: risk identification, evaluation and structuring; risk evaluation; risk planning; risk control and corrective actions.

Risks can also be of different categories, such as business-, project- or product-related risks.

Risk Identification

Risk identification is studying a situation to realize what could go wrong in the product design and development project at any given point of time during the project. Sources of risk and potential consequences need to be identified before they can be acted upon and mitigated. Experts in their own domain have intuitive methods of recognizing a risk situation. As such, the identification tools presented in this section are more general in nature and need a collaborative approach so that all aspects of the project are examined for risk situations (Ammar, Kayis, and Sataporn 2007).

The description of the risk types is as follows (Kayis et al. 2007):

1. Schedule risk – is a plan of procedures for a specific project with reference to a sequence of operations that encapsulates the milestones, task dependencies, lead times, production planning, etc.
2. Technical risk – is related to a professional trade involving mechanical, industrial or applied sciences. It includes design specific issues as well as manufacturing specific issues such as quality assurance, product/process design, technological know-how, innovation and technical support.
3. External risk – is related to any issues with regard to any parties outside of the organization (e. g. changes in customer requirements) despite the 'Design WITH' customers as the core approach adopted. Furthermore, legal, government, regulatory requirements, etc., are considered as well.
4. Organizational risk – is related to the management or administration personnel of the business. More specifically it is defined by the organizational structure, ownership, stakeholders, leadership and the organization's culture.
5. Communication risk – is the ability to effectively convey ideas and information within the company and externally to suppliers and customers. Communication encompasses language barriers, cultural differences and communication channels.
6. Location risk – is the physical distance/barrier between two respective parties, including their geographic location, proximity to each other, number of project sites and their size.

7. Resource risk – is the available capabilities relating to supplies or support, including material, labor, equipment and facility specific issues.
8. Financial risk – is related to monetary receipts and expenditure. More specifically, it includes currency exchange rates, inflation, budget and costs.

Several tolls can be used for risk identification, such as:

- checklists,
- an influence diagram,
- failure mode and effect analysis (FMEA),
- hazard and operability study (HAZOP),
- fault tree analysis,
- event tree analysis, and similar.

Risk Analysis

After risks are identified, their characteristics need to be assessed in order to determine whether the risk event is worth further analysis. Once it is decided that a risk event needs analysis then it needs to be determined whether the risk event information can be acquired through quantitative or qualitative means. Measurement metrics for risk also need to be determined so that these metrics can be used for computation of risk magnitude and risk analysis leading to risk mitigation plans (Amornsawadwatana 2002).

Risk is measured using two parameters: risk probability and risk consequence (*Risk Management Standard* AS/NZS 4360 1999; Chapman and Ward 1997; Conroy and Soltan 1998). Risk probability or likelihood indicates a chance of a risk event occurring, while risk consequence, severity or impact represents an outcome generated from the risk event. Risk magnitude is the product of risk probability and consequence. To measure risk magnitude, the probability and consequence of a risk event need to be determined, which constitutes the risk assessment function. In practice, the risk quantities are either quantitative or qualitative in nature. The quantitative approach to determination of risk parameters requires analysis of historical data through statistical analysis. In many instances, quantitative data are hard to achieve and are restricted to a very small domain of the problem where historical trends could be sustained. An example of quantitative data for determining risk consequence is a historical record of money spent on correcting non-compliance of tooling usually used in the fabrication of the type of product currently being developed (Ammar, Kayis, and Sataporn 2007).

Risk Evaluation

Risk evaluation is the function of risk management, where risk events need to be prioritized so that risk mitigation plans are determined either based on past experience, lessons learnt, best practices, organizational knowledge, industry benchmarks or standard practices (Ahmed et al. 2003; Amornsawadwatana and Kayis 2003). In risk evaluation, different aspects of the project – strategic, budget or schedule may be considered in light of a risk event, in order to determine risk mitigation options and incorporate the most suitable option into a mitigation plan. Several evaluation techniques that can be applied for risk evaluation are:

- decision tree analysis,
- portfolio management,
- multiple criteria decision-making method.

The multiple criteria decision-making method considers different project attributes including the negative and the positive factors of a decision (Webb 1994; Remenyi and Haefield 1996). Project attributes are weighted according to project predominance of the predefined criteria. The product of the relative weight and the score for an attribute gives a weighted score for that attribute. The project is then evaluated through a difference from a standard project attribute. If the total weighted score turns out to be positive, then the project should be selected; otherwise, the project should be rejected. This technique can be applied to risk analysis if risk events are compared to standard events and weighted against them (Ammar, Kayis, and Sataporn 2007).

Risk Mitigation

Risk management attempts to study in detail all aspects of project management, so that all controllable events have an action plan or a risk mitigation plan. A reactive approach or a feed-back approach refers to risk mitigation actions initiated after risk events eventuate and can be seen as an initiation of contingency plans. On the other hand, a proactive approach or a feed-forward approach refers to actions initiated, based on the chance of a risk event occurring, such as insurance (Kartam and Kartam 2001; DeMaio, Verganti, and Corso 1994). A combination of these two approaches is applied to risk management in order to avoid risk, reduce the likelihood of risk, reduce the impact of risk, transfer risk, or to retain risk (*Risk Management Standard* AS/NZS 4360, 1999). A risk query mechanism may then be formulated through techniques presented in the fourth section of this paper and imposed on the process model through interactive or collaborative interfaces to collect quantitative and qualitative data as described in the fifth section. Risk evaluation consists of decision support systems using techniques presented in the sixth section. Risks worth investigating further due to their high chance of occurring, or high potential impacts or leading to new opportunities are then pursued, leading to being treated. This whole process of risk management is collaborative and requires incremental contributions from all participants within the organization and supplements a project management approach, which is more proactive (Ammar, Kayis, and Sataporn 2007).

In this paper we have focused on the product-related design risks which affect design-related uncertainties of the product and prolonged time-to-market of the project/product.

The risk management process blends itself to product design and development, as changes and interactions in the design stage cost less than changes initiated in the implementation phase (Salamone 1995; Jo, Parasaei, and Sullivan 1993). Ammar, Kayis, and Sataporn (2007) also say that early discovery of risk events leading to downstream losses is much more preferable than treating losses when they cannot be prevented. Thus the most crucial effect on the project and product success on the market can cause changes in the latest stages of the NPD process as well as corrective actions if and when the project objectives in NPD are not achieved, or if customer-related expectations about the product which has been developed are not fulfilled. The research is primarily focused on the analysis of the design risks which affect design-related uncertainties of the product and causes of prolonged time-to-market of the project/product.

The new technologies, computing and communication have become indispensable in every aspect of the design and manufacturing process, leading to structural changes in social and economic dimensions also in NPD.

The full scale involvement of different stakeholders in NPD at operational levels has not yet been achieved due to a lack of complete understanding of NPD projects. According to Tseng, Kjellberg, and Lu (2003) this is mainly because not every aspect of engineering design and/or manufacturing capabilities has been linked with customers and suppliers proactively throughout the process of collaborating across boundaries.

The significant impacts in NPD would be in three major areas (Kayis et al. 2007):

1. Speed of decisions in NPD (the exchange of information including requirements, drawings, models, test results, etc., dramatically reduced time to market, cost of uncertainty and inventory in product design and development).
2. Expansion of scope (web inter-connectivity integrated contributions to product design and development regardless of time, geographical distances, stakeholders, suppliers and customers anywhere around the world).
3. Degree of concurrency (people as well as machines can interact in parallel inside and outside of organizations, anywhere around the world).

Thus, to transform from designing products to designing the complete NPD process is rewarding but challenging, introducing several risks to NPD projects. This paper examines the new challenges in NPD projects in manufacturing industries which expose them to several risks.

The collaborative design process inherits several risks due to knowledge sharing, decision sharing, process sharing and resource sharing in NPD projects. In this section of the paper, product design, NPD environment and management of risks in such an environment will be discussed.

Many risks can occur at the product and project definition phase, which can affect the project results. Problems can occur in connection with on-time information sharing, collaborative decision-making, compatibility of processes and resource sharing, all of which are important for enhanced effectiveness and efficiency of the product design and development on one hand, while introducing new risks on the other. A methodology to analyze a collaborative design process and management of product design conflicts was developed by Lu and Cai (2000) and Lutters et al. (2001). Within the context of new NPD, supported by new information technologies (IT), the first stages in the NPD process must be changed from the 'Design OF' of the past, through the 'Design FOR' at present, to the 'Design WITH' in the future (Tseng, Kjellberg, and Lu 2003).

NPD projects require multiple parties to work collaboratively. Particularly with new information technologies (IT) in NPD, the numbers of participants have increased. For example, supplier collaboration early in the design reduces a product's lifecycle cost and extends a company's ability beyond its traditional boundaries to intorduce improvements and to improve the total cost of doing business together (Lutters et al., 2001). Hence, to increase the chances of success for NPD organizations, Lu and Cai (2000) emphasized the importance of collaboration between project partners during engineering design. This collaboration will eventually lead to the competitiveness of organizations, due to better knowledge utilization and sharing with every project partner and incorporating the changing design style from the 'Design OF' of the past, via the 'Design FOR' at present, to 'Design WITH' in the future. In order to successfully achieve 'Design WITH' in NPD projects, knowledge management needs to be incorporated into the risk management practices of manufacturing organizations.

Two main hypotheses related to this research have been developed:

- H1 *Undefined technical requirements for the product present an important risk related with the design uncertainty of the product. The more imprecise the technical requirements for the product before the project starts, the higher is the design uncertainty of the product after its development.*
- H2 *Unclear project objectives have a significant effect on the time-delay of NPD projects. The more imprecisely the project objectives are defined before the project starts, the greater is the time-delay on the NPD project.*

The aim of the research was to determine impact factors related with risks of new projects and products, as well as to establish their profile by:

> *Identification of the impact factors which most frequently affect design uncertainties on the NPD projects; identification of the weight of each impact factor; identification of the impact factors which most frequently affect time-delays on the NPD projects of development of white goods; and identification of the weight of each impact factor.*

In line with the findings, the study at the end focuses on developing a specific extended model of managing risks in NPD projects, which will consider the detected risks of NPD projects.

Methodology

Because the research is oriented to the NPD projects, we decided to carry out the survey among project managers with several years of experience in the field of NPD projects (table 1). The methods used were both quantitative and qualitative and a survey of questions was employed.

Prior to that, interviews were also performed with the project managers included in the research. We expected that only with such a combination of methods could we achieve the research objectives. The interviews were selected because we wanted to collect as much experience as possible from the different project managers in the field of different NPD projects, such as new products, design upgraded projects of NPD, etc. (see also table 1). Possible impact factors which affect the design risks and prolonged time-to-market of NPD projects were collected. The data collected were used to create a questionnaire which considered realistic, first-hand information from the actual environment of various projects (table 1).

The questionnaire consisted of both closed and open types of questions, and comprised two contextual contents (Questionnaire A and B, see also tables 3, 4, 6, 7, and 8). In the first stage, some impact factors which cause design-related uncertainties on the market were evaluated and in the second stage the frequency of impact factors was evaluated. Also for the second questionnaire (B1 and B2), the impact factors which affect time-to-market delay in the NPD projects were evaluated and the weight of the factors was evaluated. In the first stage the significance of the claims was marked using the extended Likert scale of measuring opinion (1, 2, 3, . . . 9, 10) (Toš 1976). In addition, participants marked the weight of the top five (from 1 to 5) factors with the biggest focus of Questionnaire A on design uncertainties, and Questionnaire B on time-to-market delay of NPD projects in the past.

The questionnaires were selected to collect individual data from the different project managers and projects (table 1) which were finished (1997-2007) and to study the following:

- Identification of the impact factors which most frequently affect design uncertainties on the NPD projects (Questionnaire A).
- Identification of the weight of each impact factor (Questionnaire A).
- Identification of the impact factors which most frequently affect the time-delay of the NPD projects of development of white goods (Questionnaire B).
- Identification of the weight of each impact factor (Questionnaire B).

TABLE 2 Background of the projects included in this research

Up to today, how many times did you participate in NPD projects?	Number of projects for total eight project managers
Totally new product for market	0 projects
New generation of existing products	25 projects
Existing product – technically improved	19 projects
Design upgrade of an existing product	36 projects
Total	80 projects

Results and Discussion

Based on the interviews with project managers, we have defined real potential reasons for design-related risks of new products, as well as the potential reasons for the time-to-market delay of NPD projects.

As table 1 shows, many of the included project managers have already participated in several NPD projects. The most common practice of project managers was in the field of managing design-upgraded new product projects (36 projects), followed by new generations of existing products (25 projects) and NPD projects which were oriented to the development of technically improved existing products (19 projects) (table 2).

In the study, eighty different NPD projects in the field of domestic appliances, managed by the eight project managers, were analyzed (table 2).

The primary objective of the research was to analyze the key impact factors which are related to the design uncertainties of the product after the project is finished. Questionnaire A was used (see results in table 3).

The most frequently detected impact factor in this research was a lack of time for testing technical solutions (average mark 9.375 on the Likert 1–10 scale) related to product design. The second most frequent cause that was detected was the fact that the technical requirements for the product had not been defined (average 9.125 on the Likert 1–10 scale). That presents a very strong issue which has its foundations in the market/customer definition of its needs at the beginning of the NPD project, which shows a lack of planning management in the NPD projects. The technical definition of the product is the final result as an output of the definition of customer needs. The third most frequent cause detected was the lack of knowledge in the field of managing NPD projects (average 8.50 on the Likert 1–10 scale), and the fourth was the lack of time for developing solutions in the NPD process (average 8.375 on the Likert

TABLE 3 Results of the analysis of the impact factors related to the design-related risk of the product

Which of the following impact factors, in your opinion, most frequently cause design-related uncertainties of the product? For each statement use the Likert 1–10 scale (1 – factor does not affect design uncertainty, 10 – factor extremely affects design uncertainty of the product).

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1	Lack of time for testing solutions	9.375	8	10	0.92	14.26	5.64
2	Technical requirements for the product are not defined	9.125	6	10	1.36	13.88	5.04
3	Lack of knowledge in the field of management	8.50	4	10	2.00	12.93	4.33
4	Lack of time for development of solutions	8.375	7	10	1.06	12.74	3.58
5	Insufficient control over research and development (R&D) department	8.125	5	10	1.81	12.36	7.39
6	Lack of human resources	8.00	7	10	1.07	12.17	6.00
7	Lack of know-how for testing	7.50	5	10	1.85	11.41	9.16
8	Lack of know-how in R&D	6.75	5	9	1.83	10.27	9.57

NOTES Column headings are as follows: (1) rank, (2) impact factor on the design-related risks of the product, (3) average mark (1–10), (4) min. mark, (5) max. mark, (6) standard deviation, (7) % of all points, (8) t-value at $\alpha = 0.05$ (95% certainty).

1–10 scale). These results very clearly show the lack of planning in NPD projects, which results in the occurrence of many risks which could already have been managed in the early stages of the planning phase of the project.

The aim of the detailed analysis of the impact factors which are related to the design uncertainties of the product after the project is finished was also to identify the weight of the factors (see table 4). The results show that the strongest influence on the design uncertainty of the product was undefined technical requirements of the product (average 3.125 on the Likert 1–5 scale), followed by the lack of time to test solutions (average 2.375 on the Likert 1–5 scale).

By combining the data collected from Questionnaire A (table 3 and table 4), the summary is that undefined technical requirements for the product and the lack of time for testing present the most common risks in an NPD project, which cause design-related uncertainties of the product on the market. Thus, we can claim that Hypothesis H1 can be confirmed.

TABLE 4 Results of the analysis of the impact factors related to the design-related risk of the product

Which of the following impact factors, in your opinion, has the strongest effect on the design-related uncertainties of the product? For each statement use the Likert 1–10 scale (1 – factor has a very small effect on the design-related uncertainty; 10 – factor has a very big/significant effect on the design-related uncertainty of the product).

(1)	(2)	(3)	(4)
1	Technical requirements for the product are not defined	3.125	22.32
2	Lack of time for testing solutions	2.375	16.96
3	Lack of human resources	2.25	16.07
4	Lack of time for development of solutions	2.125	15.18
5	Insufficient control over research and development (R&D) department	1.625	11.61
6	Lack of knowledge in the field of management	1.25	8.93
7	Lack of know-how in R&D	0.75	5.36
8	Lack of know-how for testing	0.625	4.42

NOTES Column headings are as follows: (1) rank, (2) impact factor on the design-related risks of the product, (3) average mark (1–5), (4) % of all points.

TABLE 5 Combined results of tables 3 and 4 together (impact factors are multiplied with weight from table 4)

(1)	(2)	(3)	(4)	(5)
1	Technical requirements for the product are not defined	9.125	3.125	28.5
2	Lack of time for testing solutions	9.375	2.375	22.2
3	Lack of human resources	8.00	2.25	18.0
4	Lack of time for development of solutions	8.375	2.125	17.8
5	Insufficient control over research and development (R&D) department	8.125	1.625	13.2
6	Lack of knowledge in the field of management	8.50	1.25	10.6
7	Lack of know-how in R&D	6.75	0.75	5.0
8	Lack of know-how for testing	7.50	0.625	4.6

NOTES Column headings are as follows: (1) rank, (2) impact factor, (3) average value from table 4, (4) average value of the impact from table 3, (5) column 3 × column 4. $\alpha = 0.05$ (95% certainty), factor is significant at $t > t$ min = 2.14.

The second objective of the research was to identify the impact factors which most frequently affect the time-delay on the NPD projects of development and determine the weight of each impact factor. The research was performed using Questionnaire B (see results in tables 6 and 7). The

TABLE 6 Results of the analysis of the biggest impact factors related with the time-delay of the NPD project

Which of the following impact factors, in your opinion, most frequently affect the time-delay of the NPD project? For each statement use the Likert 1–10 scale (1 – factor has a very small effect on the design-related uncertainty, 10 – factor has a very big/significant effect on the design-related uncertainty of the product).

(1)	(2)	(3)	(4)
1	After a major change to the product no adaptation of the project plan follows	9.50	5.2
2	Unrealistic time plan	8.75	5.2
3	The role of the project manager is not clear (limited authority)	8.75	8.3
4	Waiting for a decision	8.50	7.1
5	Unrealistic objectives	8.38	6.8
6	Frequent changes during the project	8.25	7.0
7	Sources for the project are not available on time	8.13	7.3
8	Project objectives are not clear	8.00	4.23
9	Lack of human resources on the project	8.00	6.8
10	Responses of the suppliers	7.88	7.7
11	Not proper project management/leadership	7.88	16.2
12	Lack of control over the project	7.63	7.02
13	Relations with the environment are not clear (organizational)	7.38	9.4
14	Responses of other support functions	7.25	4.5
15	Inadequate human resources for support	7.25	6.23
16	Lack of competences of the project team	7.25	9.7
17	Decisions are not based on an expert basis	7.00	6.9
18	Frequent wrong decisions	6.88	2.6
19	We are not using the prescribed product development process	6.63	16.9
20	The phases of the project are not clear	6.38	6.6
21	Unclear role of the team members	6.25	16.0
22	NPD process is not adequate	6.25	14.0
23	Working environment is not adequate	6.00	11.16

NOTES Column headings are as follows: (1) rank, (2) impact factor on the design-related risks of the product, (3) average mark (1–10), (4) t-value at $\alpha = 0.05$ (95% certainty). $\alpha = 0.05$ (95% certainty), factor is significant at $t > t$ min = 2.14.

most frequent impact factor for time-to-market delay on NPD projects was that after a major change to the product during the NPD project, no adoption of the project plan follows (average 9.500 on the Likert 1–10

TABLE 7 Results of the analysis of the biggest impact factors related to the time-delay of the NPD project

Which of the following impact factors, in your opinion, has the strongest effect on the time-delay of NPD projects? For each statement use the Likert 1–10 scale (1 – factor has a very small effect on the design-related uncertainty; 10 – factor has a very big/significant effect on the design-related uncertainty of the product).

(1)	(2)	(3)	(4)
1	Project objectives are not clear	2.375	15.32
2	Unrealistic time plan	2.125	13.71
3	The role of the project manager is not clear (limited authority)	2	12.90
4	After a major change to the product no adaptation of the project plan follows	1.5	9.68
5	Unrealistic objectives	1.375	8.87
6	Waiting for a decision	0.875	5.65
7	Not proper project management/leadership	0.875	5.65
8	Lack of human resources on the project	0.625	4.03
9	Frequent changes during the project	0.625	4.03
10	Lack of control over the project	0.625	4.03
11	Responses of other support functions	0.5	3.23
12	Sources for the project are not available on time	0.5	3.23
13	NPD process is not adequate	0.375	2.42
14	Responses of the suppliers	0.375	2.42
15	Inadequate human resources for support	0.25	1.61
16	We are not using the prescribed product development process	0.25	1.61
17	Relations with the environment are not clear (organizational)	0.125	0.81
18	The phases of the project are not clear	0.125	0.81

NOTES Column headings are as follows: (1) rank, (2) impact factor on the design-related risks of the product, (3) average mark (1–5), (4) points (%).

scale). The second most frequent impact factor is an unrealistic time plan of the NPD project (average 8.750 on the Likert 1–10 scale), followed by limited authority of the project manger (average 8.750 on the Likert 1–10 scale). That can be related to the planning phase of the project, where also risk management must be considered. In the second stage of Questionnaire B (table 7) also the weights of the impact factors from table 6 were defined (table 7).

With Questionnaire B, we analyzed which of the impact factors have the biggest influence on the time-delay of the product after the project

TABLE 8 Combined results from tables 6 and 7

(1)	(2)	(3)	(4)	(5)
1	Project objectives are not clear	8.00	2.375	19.00
2	Unrealistic time plan	8.75	2.125	18.59
3	The role of the project manager is not clear (limited authority)	8.75	2	17.50
4	After a major change to the product no adaptation of the project plan follows	9.50	1.5	14.25
5	Unrealistic objectives	8.38	1.375	11.52
6	Waiting for a decision	8.50	0.875	7.44
7	Not proper project management/leadership	7.88	0.875	6.90
8	Frequent changes during the project	8.25	0.625	5.16
9	Lack of human resources on the project	8.00	0.625	5.00
10	Lack of control over the project	7.63	0.625	4.77
11	Sources for the project are not available on time	8.13	0.5	4.07
12	Responses of other support functions	7.25	0.5	3.63
13	Responses of the suppliers	7.88	0.375	2.96
14	We are not using the prescribed product development process	6.63	0.375	2.49
15	NPD process is not adequate	6.25	0.25	1.56
16	Relations with the environment are not clear (organizational)	7.38	0.25	1.85
17	The phases of the project are not clear	6.38	0.125	0.80
18	Inadequate human resources for support	7.25	0.125	0.91

NOTES Column headings are as follows: (1) rank, (2) impact factor on the design-related risks of the product, (3) average mark (1–10) from table 6, (4) average mark (1–5) from table 7, (5) column 3 × column 4.

is finished. For data collection, we used a closed questionnaire in which participants, according to their opinion, marked from 1–5 the top five impact factors. Results are shown in tables 7 and 8.

Unclear project objectives, an unrealistic time plan, and limited authority of the project manager were detected as the impact factors which have the biggest effect on the time delay of NPD projects, also by considering the weights of each factor (table 7). Hypothesis H2 can be confirmed.

As presented in this article, today's known risk management models are mostly general and define a risk management process that is divided into several stages, such as: risk management planning, risk identification, risk analysis, risk response planning, and risk monitoring and control. General models of risk management do not offer us a precise solution for managing risks in NPD projects. The solution would be to study impact factors and to develop an extended model for project risk management in the planning phase, which would systematically study this problem for NPD projects. Many models exist which consider project risk management as a multiple stage process. They are mainly general, but for specific projects, such as NPD projects, we need to develop an extended model which will consider special requirements for certain NPD projects. We have therefore decided to examine the characteristics of NPD projects to develop a more specific model of managing risks in NPD projects.

Different authors observe project risk management as a multi-stage process (table 2). Regarding the results of the analysis and past practical experiences an extension of the basic risk management model (Picture 1) has been developed. Including some additional key areas which are based on this research and which are crucial for the success of NPD projects, an extension of the basic model has been developed:

Key sub-areas in NPD projects for the risk planning phase are:

- project objectives;
- organization of the project;
- project human resources;
- NPD process.

Regarding the research in this paper, all significant influence factors are included in the risk planning activities in NPD.

Extended Model of Project Risk Management in NPD Projects

Further on, some sub-criteria for each key area are presented as questions for project managers in the NPD project planning phase.

Key Area 1: Project Objectives

1. Are the project objectives clear and defined?
2. Are the project objectives defined by agreement or defined by authoritative command?
3. Are the project objectives SMART? (Specific, measurable, ambitious, realistic, time achievable)
4. Does the project team know all the objectives of the project before the start?

5. Do the project team members agree with the objectives?
6. Have the project objectives been defined with the cooperation of middle and operational management?
7. Has the project been planned regarding objectives and available resources?
8. Is the time plan of the project defined authoritatively by top management?
9. Is the project time plan dynamically adopted in accordance with resources?

Key Area 2: Organization of the Project

10. Do we have the project management of the project defined? (Members, roles, responsibilities, relations)
11. Does the project have a decision-making organ?
12. Is our project divided into some sub-phases?
13. Are the contents of the sub-phases of the project clear?
14. Did we plan a testing phase of the product inside the time-plan of our project?
15. Are the conditions of progressing from one to another phase of the project clearly defined?
16. Did we plan decision points in the project for all sub-phases of the project?
17. Are the roles of the project management organs and members clear?
18. Did we plan expert-based decision-making at the decision points?
19. Did we plan for decision-making time in the time plan?
20. Did we plan support of other functions in the company? Have all needs been detected and planned?
21. Do we have all support activities for regular team work in place? (Premises, computers, rooms, communication tools, etc.)

Key Area 3: Project Human Resources

22. Have human resources been planned as will be required by our needs on the project?
23. Do we have clear criteria for team members' selection?
24. Did we define a role of each team member on the project?
25. Did we plan for team members' full-and part-time work on the project?

26. Do we have a system of evaluation and motivation of individuals on the project?
27. Did we consider cooperation of all major activities and necessary outsourcing with cost estimation?

Key Area 4: NPD *Process*

28. Do we have a clear marketing and technical definition of the product before the start of the development phase?
29. Are we planning interdisciplinary support in the NPD process?
30. Do we have an information system for efficient data and information exchange and communication?
31. Did we plan prototype testing and confirmation of the solutions before regular tool orders?
32. Do we plan to find suppliers of the components based on the finished and tested solutions and final drawings?
33. Do we have a system for tracking the changes in the design of the product and components?
34. Do we have the support of contract management with suppliers?
35. Do we have clear traceability from marketing requirements to technical requirements for the components of the product?
36. Are we planning a validation of the product, testing and certification of the solution from real tools and materials before the market launch?
37. Do we have a clear product quality/production/service plan and clear criteria for the product launch?
38. Do we have a detailed technology, market and product development plan synchronized?

Conclusion

The business environment and challenges of NPD projects have always been interchangeable. Consequently, also some models which study project risk management are changing. None of the models of project risk management available in the literature is detailed and related to the NPD projects, especially white goods. Authors mainly study a general approach, but rarely specific products and projects. Different authors mention several step processes with no detailed insight into each step, and none of them relate risks of design uncertainty and factors which affect a late project finishing time. General models are usually too general to be effective, but precise ones are usually very difficult to manage. A balanced attitude must be used to achieve the goals of NPD projects.

For special types of NPD projects, a detailed view into some factors which cause the risks must be considered. Undefined technical requirements for the product present an important risk related to the design uncertainty of the product. The more imprecise the technical requirements for the product before the project starts, the higher is the design uncertainty of the product after its development. Based on our results, an extended model of risk management in the planning phase in new product development projects has been developed and presented.

According to the new approaches in project management and changes and new challenges in today's environment, we may expect that also new models will be additionally developed .

All the mentioned authors study risk management on the projects from a general perspective. Managing an NPD project from a risk management perspective requires detailed information about the specific product in development; therefore, further investigation and research is oriented in NPD to white goods products. A general model of the NPD process which would suit any company and project does not exist. An adopted model of the NPD process for specific projects is needed. The basic element of this model includes risk management, which must also be developed regarding specific requirements for NPD projects in the white goods industry. For the successful achievement of NPD project objectives, we need to consider risks related to the special type of the projects. This requires that we know the key risk factors which cause risk in specific NPD projects. Project management practice and theory consists of several key areas which enable sophisticated managing of the projects. One of them is project risk management.

Research shows that undefined technical requirements for the product present an important risk related to the design uncertainty of the product. The more imprecise the technical requirements for the product before the project starts, the higher is the design uncertainty of the product after its development. Unclear project objectives have a significant effect on the time-delay of NPD projects. The more imprecisely the project objectives are defined before the project starts, the greater is the time-delay on the NPD project.

Both conclusions reflect a lack of planning in the early phases of NPD projects. These phases consist also of project risk management study. By studying risks in the early stages of NPD projects, we can systematically reduce the effect of risk on the project. Consequently, the success of the project and product which has been developed can be increased.

Based on the research findings, an extended model of risk planning in NPD has been developed. It consists of many sub-areas where results of this research show us opportunities for improvements, such as risk planning for the NPD project objectives, project organization, project human resources and NPD process.

This research presents a basis for future studies. One might be on the influence of virtual teams on the efficiency and success of the projects which include also the study of risk management of virtual projects.

Limitations

The research is limited to NPD projects. Analysis is oriented to the specific environment of NPD projects in the domestic appliances industry. A limitation is presented by data collected with this type of questionnaire.

Implications

The developed model of risk management can be applied to any R&D project which deals with NPD. The model can be used and applied in practice because it is based on the latest literature findings, and because of the results of the research and the strong background of the author in this field in practice. The findings can be useful for consultants, project managers and project teams and managers in companies which perform NPD projects, as well as for further studies in this field.

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