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“Managerial Success Factors in New Product Development: The Case of the Injection Molding Industry”

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Ronald Mitterhofer

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List of abbreviations

ERP	Enterprise resource planning
MGT	Management (used in tables and figures)
OB	Obligation book
OEM	Original equipment manufacturer
PD = NPD	Product development = new product development [*]
PDMA	Product development and management association
PDP = NPDP	Product development process = new product development process [*]
PM	Project management
Q1, Q2,..., Q5	Questionnaire 1-5
SME	Small and medium enterprise
TTM	Time-to-market

^{*} Used synonymously throughout thesis

1 Introduction

This work deals with new product development (NPD) in the injection molding industry. In line with the goals of the Pro4Plast project, the aim of this thesis is to evaluate the status quo of NPD. For this purpose we follow a case study approach incorporating data derived from a survey among companies participating in the project. The results of this case study in the injection molding industry are discussed with regard to insights derived from a literature review on new product development processes (NPDP), its evaluation criteria and success factors.

1.1 Motivation

Product development (PD) or NPD is defined by Krishnan and Ulrich (2001) as “*the transformation of a market opportunity into a product available for sale*” (p. 1). According to Griffin (1997) these processes are more complex for manufactured goods firms than for service firms. As Fixson and Park (2008) explored, such processes accumulate in industries in which technologies underlie a frequent change. The European injection molding industry with its 1.5 million employees and an annual turnover of 150 billion Euros – mainly generated by small and medium enterprises (SME) – is a driving force in introducing new technologies (Daucher, 2007). Therefore technology transformations occur frequently when it comes to the field of injection molding. Nevertheless the industry as a whole attempts to abandon the still far spread trial-and-error method of developing new products which leaves its full potential untapped.

This work is part of a collective research project in cooperation with the European Commission, called Pro4Plast. A total of 46 SME as well as original equipment manufacturers (OEM) took part in this project. From very small family-type injection molders like Buzek with two employees working in the product and tool development departments to global players like Linde with 450 tool developers, the spectrum of companies is broad. The participating companies come from all over Europe: Spain, Italy, Netherlands, Austria, Germany, Poland, Czech Republic, Slovakia, Hungary and Slovenia.

The main goal of this project is to broaden the knowledge base for both SME and OEM in order to strengthen their competitive position (Daucher, 2007).

In order to achieve this goal, this project sets out to develop a framework for new product development processes with three goals in mind:

- First, reduce the time-to-market (TTM) significantly. The term “time-to-market” describes the lead time for product development from a product being conceived until its being available for sale (Alfonso et al., 2008).
- Second, create a common platform which unifies and standardizes the different approaches which are used. The need for a structured decision process arose from a situation in which many companies had their own way of developing products. There are great differences between them: some companies had no process defined at all; some used pencil and paper concepts, some had a software-controlled Stage Gate process already in action.
- Third, reduce the costs of new product development processes. This is the immediate consequence of the former two goals but still a goal in its own right.

A questionnaire was developed to evaluate the status quo at the participating companies. The questionnaire was designed by executives of the Pro4Plast board which also conducted the survey. Participating SME and OEM were asked to analyze their new product development processes in five different areas: simulation technology experiences, status quo PD-procedure, existing product development process (PDP) and obligation books, selection of existing parts for optimization, and selection of new parts for development with simulation.

The contribution of this thesis to the project is to examine the framework of factors on a managerial level which influence the quality of new product development processes based on the survey among project participants.

1.2 Research questions

The directive of this project is twofold: (1) to cut the TTM and (2) to cut the costs of NPDPs for the companies in this project. Therefore the long-term objective is to provide companies which have not yet applied standardized development processes with a framework to do so.

In order to achieve the above stated goals it was necessary to analyze the data acquired by the survey in order to (1) distinguish success factors and design factors possibly influencing this success, (2) identify configurations of these design factors which correlate with the factors enabling the effective and efficient implementation of new product development processes which span across company borders (i.e. influence factors), and (3) to group the companies according to their strengths within these success factors to a group of best cases and compare them to the rest. These tasks are at the core of our research.

1.3 Methodology

The data acquired by the survey of the Pro4Plast board is orchestrated with insights from literature and additional data to a case study of PD in the injection molding industry.

The standard approach for this kind of study and data would have been to formulate a theory, derive hypotheses, construct a questionnaire to conduct a survey and analyze the results. As laid out in detail in chapter 6.2, we entered the process when the first responses returned. To meet good scientific practice and avoid a process called harking², we rather opted for an explorative study. Therefore we chose a data-driven qualitative methodology. As Strauss and Corbin (1998) stated, *“Theory derived from data is more likely to resemble the ‘reality’ than is theory derived from putting together a series of concepts based on experience or solely through speculation (how one thinks things ought to work).”* Our method of choice therefore is similar to the method of grounded theory (Glaser and Strauss, 1967; Glaser, 1992).

We identified what we called “success factors” within the questionnaires and related them to the structure of and responsibilities within the PDP. This was done using cross tabulations in

² Harking which stands for “Hypothesizing After the Results are Known” (Kerr 1998)

combination with a chi-squared test of goodness of fit (Snedecor and Cochran, 1989) as this method is suited for a smaller number of cases.

1.4 Structure

After this introductory chapter, the remainder of this thesis is structured as follows.

Chapter 2 reviews the current state of literature in the field of PD. The focus lies on PDP, evaluation criteria for PD and PDP, and factors influential to the success of development projects. The method of evaluation is discussed and justified in Chapter 3, which deals with qualitative data analysis in general and the case study approach in particular. Chapter 4 provides information on the data incorporated in the case study, especially the survey conducted by the Pro4Plast board and the questionnaire used. The results of the case study are provided in Chapter 5. Finally, Chapter 6 summarizes the main findings of this thesis and provides managerial implications.

2 Literature overview

This chapter reviews literature on the main topic of the Pro4Plast project which is NPD, its process and the improvement of both. While Pro4Plast focuses on the injection molding industry we accumulate findings irrespective of industries. The chapter discusses the definition and scope of NPD, illuminates its processes, presents different approaches and measures of its success, as well as its success factors identified in literature.

2.1 New product development

The first work which gave a broad overview over and some structure to a relatively unexplored field of NPD was the one of Brown and Eisenhardt (1995) who reviewed the major works from 1969 to 1995. To them NPD “*is among the essential processes for success, survival, and renewal of organizations, particularly for firms in either fast-paced or*

competitive markets” (p. 344). Therefore their perspective can be categorized as an organizational one. Krishnan and Ulrich (2001) expand this view by defining PD “*as the transformation of a market opportunity into a product available for sale*” (p. 1).

One important difference to the term “product development” is that NPD concentrates only on new products, whereas PD also includes the improvement of existing products.

This process includes two parallel paths: the first one consists of idea generation, product design and detail engineering; the second path engages in market research and market analysis. As the idea generation in the injection molding industry usually happens at the OEM, it is not documented within our data. That is why this work will concentrate mainly on the first path, excluding the idea generation phase.

Therefore this work defines new product development as the **process of the physical transformation of an idea into a well specified and documented product, considering managerial success factors**.

Numerous studies show that successful NPD is at the core of a flourishing company in the manufacturing industry. Ettlie (1995) found that companies which introduce new products successfully find themselves with significant market share increases and without significant affects on costs, so that they become more profitable. Eisenhardt and Martin (2000) discuss the example of Toyota which has gained competitive advantage in the automotive industry mainly due to its superior product development skills. Clark and Fujimoto (1991) found that it takes U.S. and European car companies nearly twice as long (3.0 million hours in the U.S. and 3.2 million hours in Europe compared to 1.7 million hours in Japan) to design a product of comparable complexity. In these examples, the influence which NPD exerts on the success of an enterprise becomes clear.

For this process of product development, several different approaches are discussed in literature.

2.1.1 Techniques in product development

In this section we discuss the two major strategies for PD – Stage Gate and concurrent engineering – as well as the still wide-spread approach of probe-and-learn. Furthermore and irrespective of the process, there are some techniques recommended in literature that are applied in and beneficial for all types of PDP, namely frontloading and set based development.

Stage Gate

The Stage Gate process was derived from phase-review processes developed by NASA in the 1960s (Verworn and Herstatt, 2002). Their primary objective was to define and review inputs and outputs for each phase. Between phases, there are management reviews which decide whether or not a project shall be continued. The main objective of such phase-review-processes was the reduction of technical uncertainties. This is accomplished by establishing a guiding system of strict rules in order to make sure that the goals in each phase are achieved. Two disadvantages of such processes lead to the development of so called second-generation innovation processes. These disadvantages were that delays occurred, as the shift from one phase to the next could only be completed when the review process was successful. Even if all but one goal were accomplished, the whole process was on hold. The second shortcoming was that – due to its focus on the technical part of the process – not the complete innovation process was covered; marketing activities for example were excluded (Verworn and Herstatt, 2002).

Second-generation Stage Gate processes overcome some of these disadvantages. The innovation process, however, is still broken into discrete stages. The Stage Gate process, though, integrates the engineering and marketing perspective. Multifunctional teams make decisions at gates according to well-defined go/kill criteria. Moreover, the whole innovation process – from idea to launch – is covered. The most fundamental difference to first generation phase-review processes is the possibility of parallel activities in order to speed up the process (Verworn and Herstatt, 2002).

The flexibility of processes is the focus of Cooper's third-generation Stage-Gate-models as shown in Figure 1. The rule of sequentiality is further loosened due to an increasing degree of

parallel performance. They can rather be seen as guidelines than strict rules and the fluent transitions between stages speed up the PDP (Verworn and Herstatt, 2002).

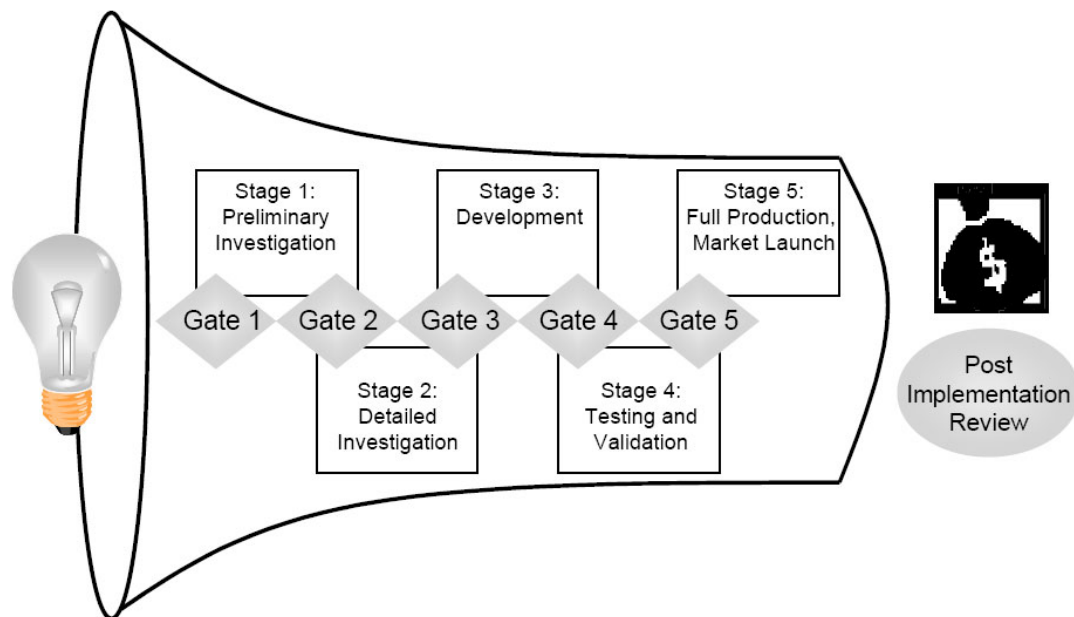


Figure 1: Third-generation Stage Gate process (source: Verworn and Herstatt, 2002)

Different types of Stage Gate processes are in use in practice. Phillips et al. (1999) for example review and compare six processes with 4 to 10 stages. They found that the underlying organizational structure plays a significant role in determining the configuration of the Stage Gate type of PDP. Organizations that employ fewer phases are often smaller and have cross-functional teams whereas such with high number of phases often are larger and have a functional orientation. In general, Phillips et al. (1999) found that there are 4 major phases: (1) preliminary concept development, (2) design development, (3) validation, (4) in-service product support. In larger organizations, phases 1 and 3 are divided into multiple smaller phases. In smaller ones, one often finds fewer phases and therefore fewer strict gates, but at the same time more informal reviews. That is why Phillips et al. (1999) conclude that in both – smaller and larger organizations – Stage Gate processes are similar.

Besides this empirical evidence that Stage Gate processes vary with the size and structure of the organization there are also some conceptual arguments for different configurations of Stage Gate processes indicating that stages can be combined to larger stages or split up to smaller steps depending on the scope of the NPDP.

Probe-and-Learn

Krishnan and Ulrich (2001) distilled approximately 200 papers from a master list of 400 which they identified as the most influential ones according to an electronic survey of 50 researchers. They conducted the survey themselves and found that there is a significant gap between theory and practice, and that most "optimal" designs in an industry are in fact the result of using engineering models in trial and error mode. Similarly, Papalambros (1995) experienced a difference between theory and practice when it comes to the use of engineering models: most design which is considered "optimal" is the result of a trial-and error approach. Lynn et al. (1996) as a result of their study see the process of market research as experimental rather than analytical. That is to say to introduce an early version of the product to a fitting initial market, learning from the probes and probing again. This is described as an iterative learning process.

Concurrent Engineering

The term concurrent engineering, also called simultaneous engineering, was used the first time in the US in 1989 (Sohlenius, 1992). It is the approach of reducing development time by using parallel activities. The development activities of concept exploration, product design, testing and production in conventional PD processes are typically controlled by only one functional department at a time. As one functional department completes its development activities, it then hands over control and responsibility to the next.

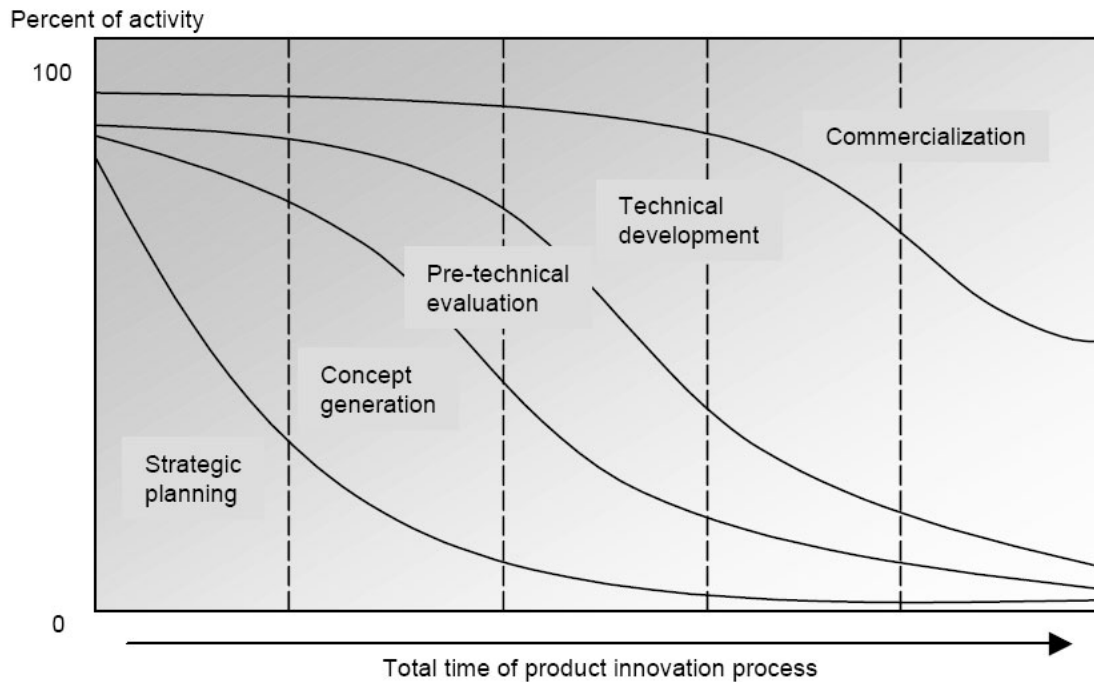


Figure 2: Simultaneous development phases (source: Verworn and Herstatt, 2002, p. 9)

In concurrent engineering, multi-functional teams share control and responsibilities and development activities overlap (Swink, 1998). This is illustrated in Figure 2. Gunasekaran (1998) regards concurrent engineering as an organizational strategy.

Front-loading

Frontloading is defined as “a strategy that seeks to improve development performance by shifting the identification and solving of [design] problems to earlier phases of a product development process” (Thomke and Fujimoto, 2000, p. 132). As depicted in Figure 3 this shift leads to a reduction of development time and simultaneously reduces development cost. In contrast to regular PD where efforts in PD are at the same rate in one phase (r_{h-f}), front-loading splits r to phases p_{tr} , p_{l-f} , and p_{h-f} with differing rate of PD – r_{l-f} and r_{h-f} . This shift up and to the left in Figure 3 leads to an earlier finish and/or more solved problems (ε)

Frontloading can be found in the production processes of such established companies as Boeing, Crysler or Toyota (Thomke and Fujimoto, 2000).

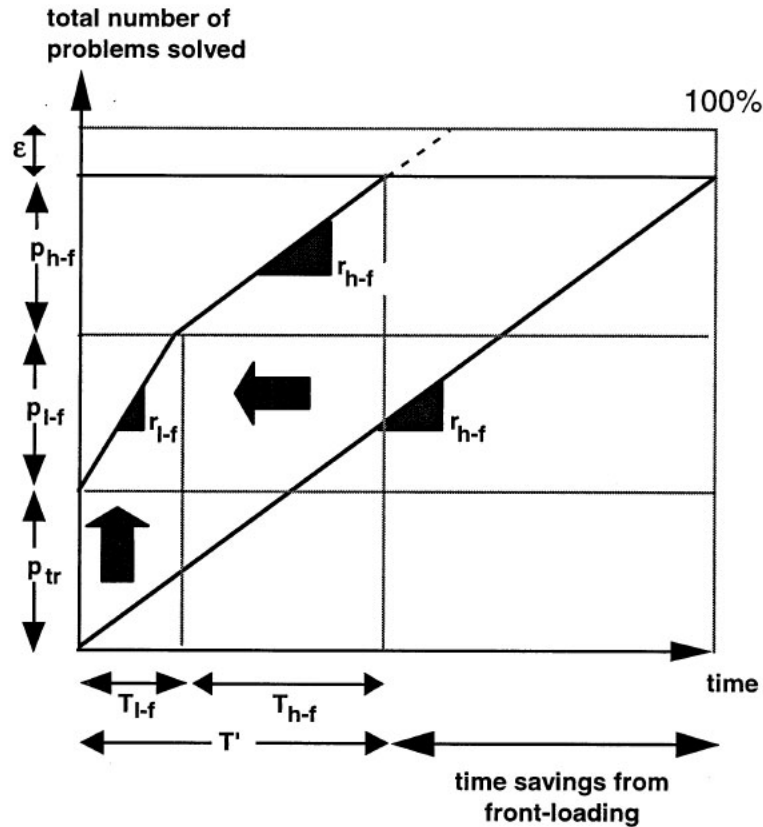


Figure 3: Front-loading (source: Thomke and Fujimoto, 2000, p.133)

Though frontloading is the paradigm applied in practice and suggested by literature, other research (Bhattacharya et al., 1998) suggests that the efficient distribution of efforts and costs over the PD cycle depends on the competitive environment of the firm. In relatively stable environments, frontloading is an efficient technique; however, in highly dynamic environments with changing preferences of customers and uncertainty about competitor's product development this might not be the case.

A viable alternative is the real-time definition of product specifications adopting the PDP to the market and competitive environment of the firm and therefore shifting these problem solving efforts to later stages of the PDP (Bhattacharya et al., 1998).

Set based development

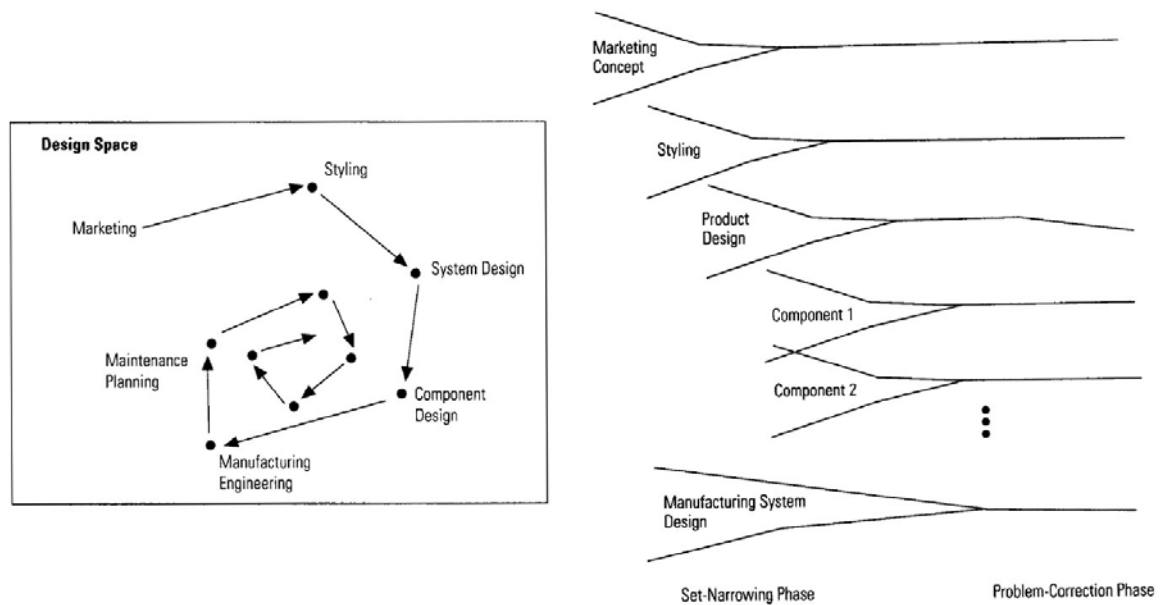


Figure 4: Point-based concurrent engineering vs. parallel set-narrowing process (source: Ward et al., 1995, p. 48, 49)

Depicted on the left side in Figure 4, there is an iterative loop, which Ward et al. (1995) describe as hill-climbing process or point-to-point search. Set based concurrent engineering, as shown on the right side in Figure 4, is a technique applied by Toyota which is not found with other car producers (Ward et al., 1995). Sets of design alternatives are evaluated simultaneously rather than one alternative at a time gradually narrowing these sets to the final solution.

2.2 Evaluation criteria for PD

The quality of the PDP is an effectiveness criterion, as the whole process is only successful if a quality is achieved which is sufficient for customers' needs. On the other hand, cost and TTM are efficiency criteria measuring usage of resources to achieve this goal. If an organization does not succeed to optimize both dimensions simultaneously, it risks a potential goal conflict between these success factors.

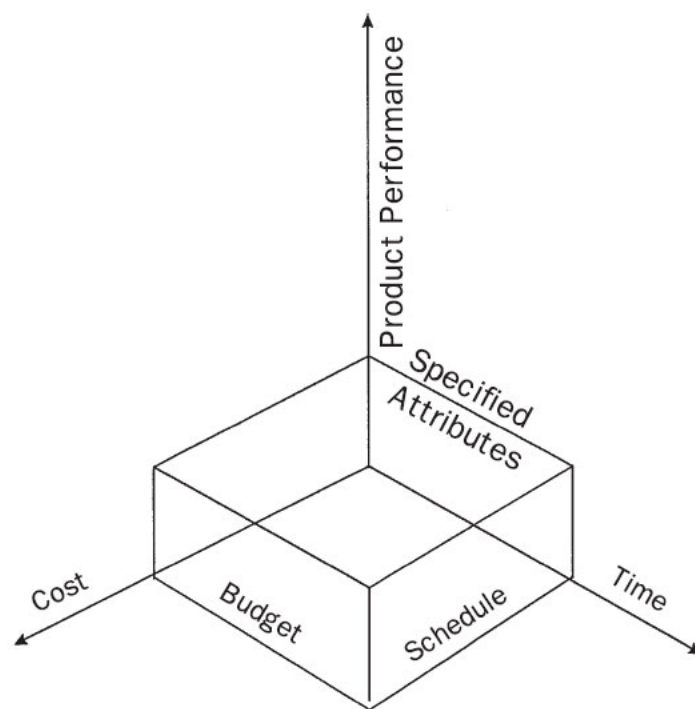


Figure 5: The triple constraint (source: Phillips et al., 1999, p. 290)

In the concept of triple constraint (Phillips et al., 1999) the interdependence between the performance of the product (reliability, value to customer), the PD time which determines market entry time and PD costs as they influence the product costs is explained. To Phillips et al. (1999) these continually changing factors affect the PDP within the organization. They are not, however, mutually exclusive as depicted here, each constraint can directly affect another. They base their definition of PD success on the successful optimization of all three dimensions.

2.2.1 Maximizing the quality of PDP

Nilsson-Witell et al. (2004) showed that programs assuring the quality of PDPs have mixed success. They identified the following criteria which separated successful PDP processes from the rest. Instead of management being in charge of improvements of the PDP on its own, each and every employee should be involved in order to make these changes sustainable. Nilsson-Witell et al. (2004) also suggest that multiple improvement programs which focus on different issues should be applied. However, all these programs should be united in a concerted effort regarding strategy, time, scope and resources. They also found that a critical mass of quality principles should be adopted. Cooper and Kleinschmidt (1987) also found that quality commitment is most important. They suggest augmenting the quality of execution, minimizing the taking of shortcuts, committing to pre-development work, defining the product in detail, executing go/kill decision points in the process and designing the process in a flexible manner.

One approach worth mentioning is called “House of Quality” (Herstatt and Verworn, 2007). It is an instrument within the quality function deployment which aims at translating the voice of the customer into the language of the engineer. Customer requirements of a new product which are detailed in the requirement specification are transformed into technical specifications respectively measurable product and process parameters in the obligation book.

2.2.2 Minimizing the cost of PDP in relation to product lifecycle cost

Several scholars (Powell and Buede, 2006; Petersen et al., 2005; Wynstra et al., 2001) argue that during the set up of a new product development system about 20% of the actual lifecycle cost for the system has been spent but about 80% of the lifecycle cost of the system is committed based upon the decisions that have been made during the engineering development process. Therefore mistakes in this part of the development process have far broader implications on the outcomes of the system. Herstatt and Verworn (2007) claim that according to studies 75 to 85 percent of product life cycle cost is determined within the early phases of PD during which only 5 to 7 percent of the cost are generated. Therefore they see a leveraging effect on the further course of NPDP. Labro (2006), on the other hand, finds little

support in literature for this rule of thumb. She questions if the 80/20 rule, the so-called "Blanchard 1978 statistic" is an adequate reflection of product development spending. In her extensive literature research she actually finds no empirical evidence in which this rule manifests.

2.2.3 Minimizing the time-to-market

The stream of research in this field has first been concentrated on reducing the TTM as much as possible (Adler et al., 1992; Ha and Porteus, 1992; Krishnan et al., 1992).

Cohen et al. (1996) found that there is a minimal speed of improvement capability required for profitably undertaking NPDP. They describe it as a complex function of the firm's rate of development labor expense, current performance in the market, product category demand rate, the new product profit margin, competitors' market share and time window of opportunity. They state, however, that a company should rather use the speed improvements it generates to develop a better product than to develop a product faster.

From the results of a field study, Datar et al. (1997) draw the conclusion that a concentrated product development structure should be engaged as it results in shorter prototyping time than a distributed one. This generates higher costs in engineering, but leads to shorter TTM.

Alfonso et al. (2008) analyzed the relationship between the use of NPD firm practice and the time this process takes as well as the cost it generates. They found out that the greater the reduction in TTM, the greater is the probability of its market success.

2.3 Success factors

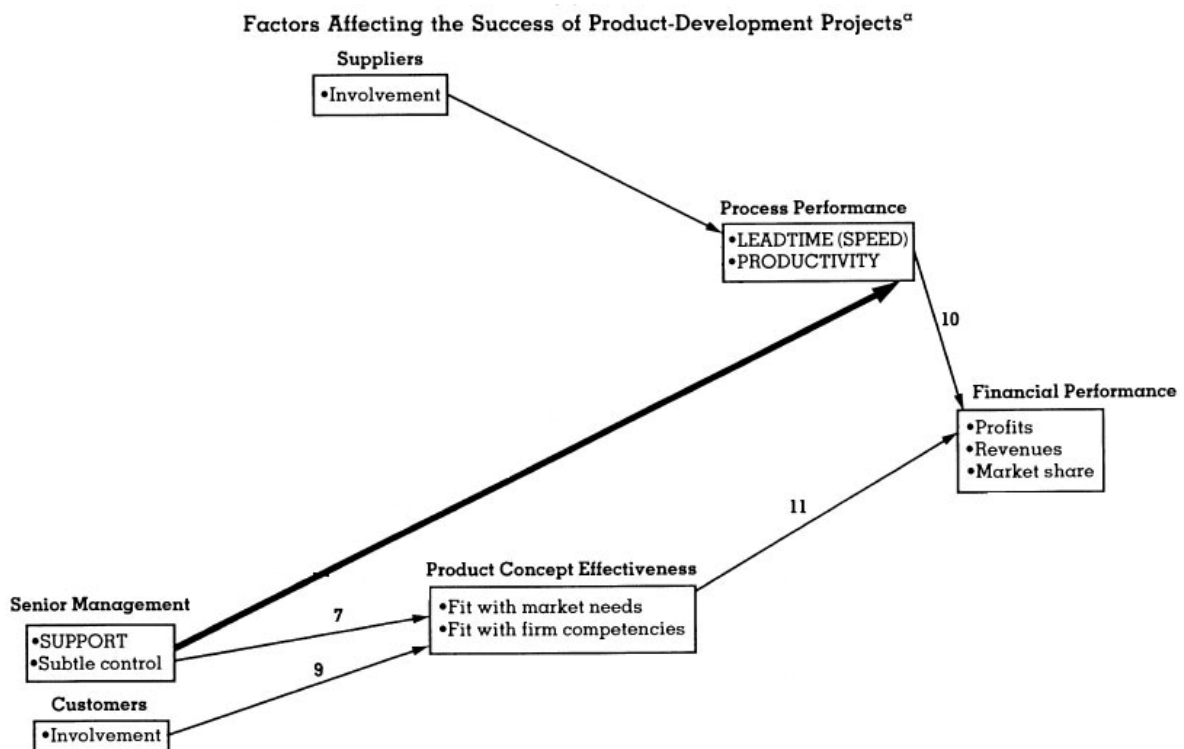
Alfonso et al. (2008) found that in the literature they reviewed the following six success factors emerged repeatedly: top management support for innovation; research and development; marketing and manufacturing competence and coordination; involvement of suppliers and customers in the design process; product quality; nature of market; and development time.

These findings are in line with previous research in the context of the Stanford Innovation Project (Zirger and Maidique, 1993). The most notable parallels in their results are internal organization (including careful planning) and top management support as well as market factors.

2.3.1 Stakeholder involvement

According to Brown and Eisenhardt (1995), other scholars have focused on the speed of new product development as a measure for success. This led them to the conclusion that a focus on internal organization with early cross-functional, customer and supplier involvement as well as visible top management support proves essential for minimizing development time.

From their meta-analysis of literature Brown and Eisenhardt (1995) developed a framework of factors influencing the success of PD projects which is shown in Figure 6.



^a Capital letters and thickened lines indicate robust findings.

Figure 6: Factors affecting the success of product-development projects (adapted from Brown and Eisenhardt, 1995, p.346)

It shows the players (suppliers, project leader, senior management and customers) and how they influence immediate (process performance and financial performance) and mediate outcome variables. The arrows show the connection between these elements and a thick one – as the caption of the graphic reads – indicates robust findings. The largest influences on process performance according to Brown and Eisenhardt (1995) are team composition, team group process and senior management, as well as the influence of a project leader on team organization of work respectively team group process. This means that all of these findings are well supported in literature.

User / customer

Brown and Eisenhardt's (1995) meta-analysis of PDP literature found that *“market pull (i.e. identifying and understanding users' needs) was substantially more important to the success of products than technology push, and thus a cross-functional view was a key component of product success”* (p. 348). Other scholars added the emphasis on new product development failure and found factors preventing from that (for example understanding users' needs, attention to the market, efficient development and seniority leadership).

In his examination of large firms, Robinson (1990) conversely showed that the most important factor affecting market share was superiority over competitive products and that compatibility with customer preferences did not matter. Lynn et al. (1996) made a point from four cases they studied in-depth that customers often do not see the need for an innovation which changes their routines.

Top management

Imai et al. (1985) rethink the role of senior management. In their opinion, the best influence on NPDP can be exerted by “subtle control” instead of just playing a supportive role. This means that it is advisable for senior management to communicate a clear vision of objectives to NPD teams while at the same time allow them to work autonomously within the discipline of that vision.

When it comes to top management involvement – which Cooper and Kleinschmidt (1987) call corporate commitment – they found that senior management commitment to risk-taking

product innovation, clear communication from senior management about the role and importance of NPD, the provision of funds and resources for product development, the support of senior management in case of difficulties or major new product decisions, and technical literacy among senior managers are the success factors which are most relevant.

Cooper and Kleinschmidt (1987) also add the perspective of holding senior management accountable for NPD performance by linking it to their annual targets and therefore their compensation. This, of course, necessitates the annual measurement of NPD projects success, which may be more difficult than mentioned in their study.

Clark and Fujimoto (1991) added to this concept the term “heavyweight team leaders” who can be seen as “linking pins” (Brown and Eisenhardt, 1995) between the NPD team and senior management through which subtle control over the team can be exercised. Eisenhardt and Martin (2000) saw such team leaders contributing to the success of PD through fostering extensive communication links outside of the group as well as through setting a vision. They found that this is especially true when those links were used by project team leaders to allocate resources and provide a buffer from outside influences. As Clark and Fujimoto (1991) see them equal in authority and prestige to the heads of the functional divisions, their mission is (1) to ensure that product and process engineering is done concurrently and (2) to generate a tight fit between the desires of customers and the product’s many technical features. They term the latter “product integrity” (p. 18).

An interesting insight into the necessity of formal control mechanisms by upper managers is provided by Bonner et al. (2001) who found that it can have detrimental effects on project performance. According to them, projects with detailed a priori process requirements set by upper managers show delays, cost overruns and lower product as well as a team performance. They found that the manner in which team members are rewarded for their accomplishments is not related to project performance. This study generates the insight that the form of involvement of senior management determines if this involvement has positive bearings on new product development.

Bonner et al. (2001) concluded that the early and active participation by project team members in the determination of the projects operational controls is to be supported by senior

management in the form of paying attention to team member's opinions and inputs and letting them determine requirements and outcome objectives of new product development projects.

Other scholars are not so confident about the benefits of senior management support. Labro (2006) sees obtaining top management support for product development projects mainly as a coping mechanism against barriers in the value chain analysis such as difficulties to complete the implementation process or the lack of approval from the customer. Alfonso et al. (2008) discussed the correlation between the level of support and involvement of top management people and the TTM. Bonner et al. (2001) caution against intervention in decisions for which the project team is held responsible as well as changing resource allocations and cultural standard securing the project.

Supplier

Handfield and Lawson (2007) conducted a survey among 134 industrial firms throughout the world. Additionally they interviewed 35 NPD and purchasing managers at manufacturing locations in Japan and the United States. This gave them a set of qualitative and quantitative data from which they learned that involving the suppliers in an early stage enhances the feasibility of development processes as well as the degree of realism in the expectations and targets.

Handfield and Lawson (2007) found that the aspect of supplier involvement is an important factor in the outcome of the NPDP. According to them the supplier involvement in technical project assessment is important in early stage but not in late stage integration efforts, while supplier involvement in business project assessment is important in late stage integration efforts, but not in earlier stage efforts. As an example they name the automotive industry: resident engineers employed by one firm to work at another firm enhance the transfer of knowledge between the two companies improving PDP quality and reducing lead time for new models. They found that setting technical goals jointly builds more effective NPD teams, regardless of the timing of supplier involvement.

Zirpoli and Caputo (2002) state that first tier supplier involvement in co-design activities has a positive impact on both, the success of NPD and project performance measures such as cost, quality and lead time. Their finding is that when suppliers are involved at early stages of development processes their supply chain design has to reflect a cooperative approach. Zirpoli

and Caputo (2002) state that the lack of profit sharing techniques which compensate for risks taken by suppliers threatens the motivation of the latter, their attitude to cooperate and their willingness to continue investing and taking risks. They see it as given that profit-sharing procedures should be formalized.

Quezada et al. (2006) study product development practices in the automotive industry. They claim that investing in suppliers has a positive impact on final product quality and PD practices. They found that the earlier OEMs involve suppliers in NPDP, the greater is the opportunity of the supplier to improve the OEMs perception of its performance. Moreover, the early involvement of suppliers decreases the uncertainty on the supplier side and improves performance while simultaneously increasing the quality of products and communication within the supply chain.

Petersen et al. (2005) found that supplier integration into NPD is a social process and it therefore is affected by a variety of behavioral factors. They interviewed engineers, of which the majority *"expressed their initial and acute discomfort at having an external supplier participate in new product development teams, where sensitive technical information is being discussed"* (p.373). They also found that companies who were successful at supplier integration employed systematic assessments. From their findings, Peterson et al. (2005) set up a model of the spectrum of supplier integration as Figure 7 shows. It moves from none (on the left) to full supplier integration.

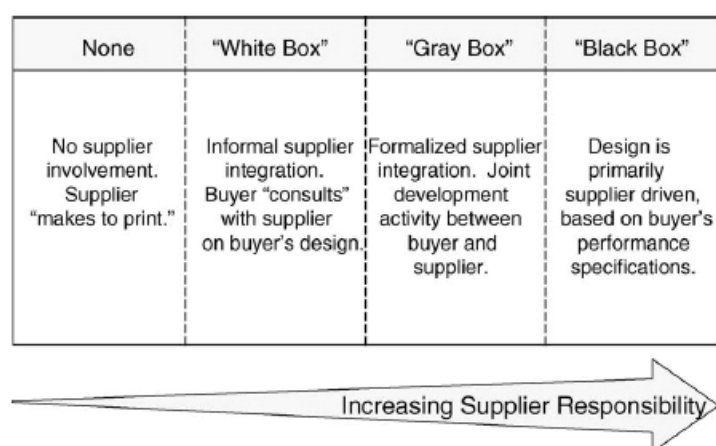


Figure 7: Spectrum of supplier integration (source: Petersen et al., 2005, p. 378.)

They saw the importance of building human connections within the buyer-supplier relationship, particularly where the supplier had black box responsibility. For example, black

box suppliers where significantly more likely to co-locate their engineers with the buyer, particularly during the early stages of the project. Co-location and other measures, such as regularly scheduled meetings, metrics reporting structures, and team workshops, are acknowledged methods of recording face-to-face communication, tacit knowledge sharing, and building trust between organizations.

As a salient success factor in the early integration of suppliers in the new product development process Peterson et al. (2005) see the leveraging of the suppliers expertise.

Alfonso et al. (2008) found the number of suppliers used in the process to have a significant impact on the TTM for a PDP process.

2.3.2 Internal organization

According to Cooper and Kleinschmidt (1987), internal organization – especially predevelopment planning, cross-functional skills as well as top management support – plays a major role.

They identified four groups of factors, which influence the success of the new product at the project level. Besides market environment these groups are the (1) strategic, (2) development process, and (3) organizational factors. Their study tried to answer the question if success at the project level can be replicated at the company level. Cooper and Kleinschmidt (1987) found that having sharp, early product definition before PD begins is as important as the existence of a formal new product process. By deploying cross functional teams and therefore generating cross functional responsibility and interfaces between departments product performance can be leveraged, especially the TTM. It says much about how they think about the empowerment of the leader of such a team when they use the word "champion" as a synonym for such a leader.

Another important point they add to research on new product development processes is that companies which generate an entrepreneurial climate for product innovation are more successful. This climate is characterized by a new product idea suggestion scheme, provision of free time or scouting time to technical employees (up to 10% to 20% of their work week)

in order to work creatively on their pet projects, financing such pet projects and teams working on the "unofficial" projects.

Eisenhardt and Martin (2000) recommend establishing routines which ensure the occurrence of concrete and joint experiences among team members. By this they understand the collaboration on fixing specific problems or the participation in brainstorming sessions. They argue that new knowledge is generated not only by people with different expertise knowing different things, but knowing those things differently. Such experiences with others on the PD team create a common experience base and language which helps building bridges between functionally distinct people. Eisenhardt and Martin (2000) illustrate their point with the example of a study investigating 18 PD projects in five big companies like Kodak and Campbell Soup. It was found that the results of PD projects which included common customer visits and feedback dominated those where simple liaisons between groups were established.

Krishnan and Ulrich (2001) proposed that at least four common perspectives in the design and development research community exist: marketing, organizations, engineering design, and operations management. They developed a decision framework which spans all four dimensions. As this work tries to highlight the PD process from an organizational perspective.

Ettlie (1995) found that companies which have focus (strategy) on and discipline (tactics) in NPD are most successful. He concludes that the success in new products can be measured by how important the development process is seen within the firm from a strategical as well as from a technical standpoint. He links organizations which have a focus on policies, practices and structures in their PDP to organizational success.

Powell and Buede (2006) used case study research to gain knowledge about the NPD. They collected the data from case studies of past military system development projects. The insights were gained from case studies about the development of different missile systems as well as military aircraft. Powell and Buede (2006) identified four factors which cause dysfunctions in the PDP. They found the highest negative impact for a combination of poor analysis of strategy, a lack of coordination, a lack of understanding of the reason of the action or the purpose, and bad identification of a local decisions global impact.

Alfonso et al. (2008) found that multifunctional teams are associated with significant reductions in the development cycle time of new products which have the highest degree of originality whilst formal processes were associated with remarkable reductions in the development cycle of new more complex products. They also make the point that TTM is positively influenced by the number of organizational functions that were integrated in the team involved in the development of new products. The simultaneity of activities during the development process and the definition of TTM as the firm's objective were also found to have a significant positive impact (Alfonso et al., 2008).

Datar et al. (1997) draw the following conclusions from their analysis from a field study:

A concentrated PD structure results in shorter prototyping time than a distributed one. A distributed structure, however, is superior in reducing the time from prototyping to volume production. In both structures, a longer prototyping time shortens time to volume production. The reduction of time to volume production is greater in the distributed structure. Higher levels of engineering expenditures shorten the time to volume production. The burdening of the development process due to do large number of concurrent productions or potential customers increases the prototyping time and time to volume production. The ability to handle such burdens differs marginally across the two structures.

2.3.3 Market and industry structure

Auster (1992) first established a connection between NPD and the life-cycle of an industry. Their findings were that as these stages stand for different technological, environmental, and competitive conditions, they exert influence especially in the later stages of NPD.

The Stanford Innovation Project (Zirger and Maidique, 1993) found among different internal also market factors to have a significant influence on the success of NPD. Among the findings of a Product Development and Management Association (PDMA) survey industry structure had an influence on the complexity of processes (Griffin, 1997). Tatikonda and Montoya-Weiss (2001) take a resource-based view to identify two sources of market influences which they consider as external uncertainties: (1) market newness, by which they understand the degree of familiarity with the product and its target market and (2) environmentally caused disruption, which to them is the degree of influence, events external to the development exert. Paulson Gjerde et al. (2002) created a dynamic program which helps determining which

bundles of features to include in a new product by calculating with cost, projected revenues and the external frontier of technology. Another external factor they see in price-sensitive customers who value innovation. Although a point can be made to regard customers as an outside influence (as they build the demand in a market surrounding an organization), as discussed above, this thesis considers them as core stakeholders in product innovation processes.

Paulson Gjerde et al. (2002) found that a fast-moving exogenous technology frontier increases innovation frequency. In addition to the listed external aspects of innovation processes, they see alliances as influential factors.

Ettlie (1995), however, in his study of 43 manufacturing firms across several industries in the US found no evidence that industry structure makes a difference in NPD.

2.3.4 Summary

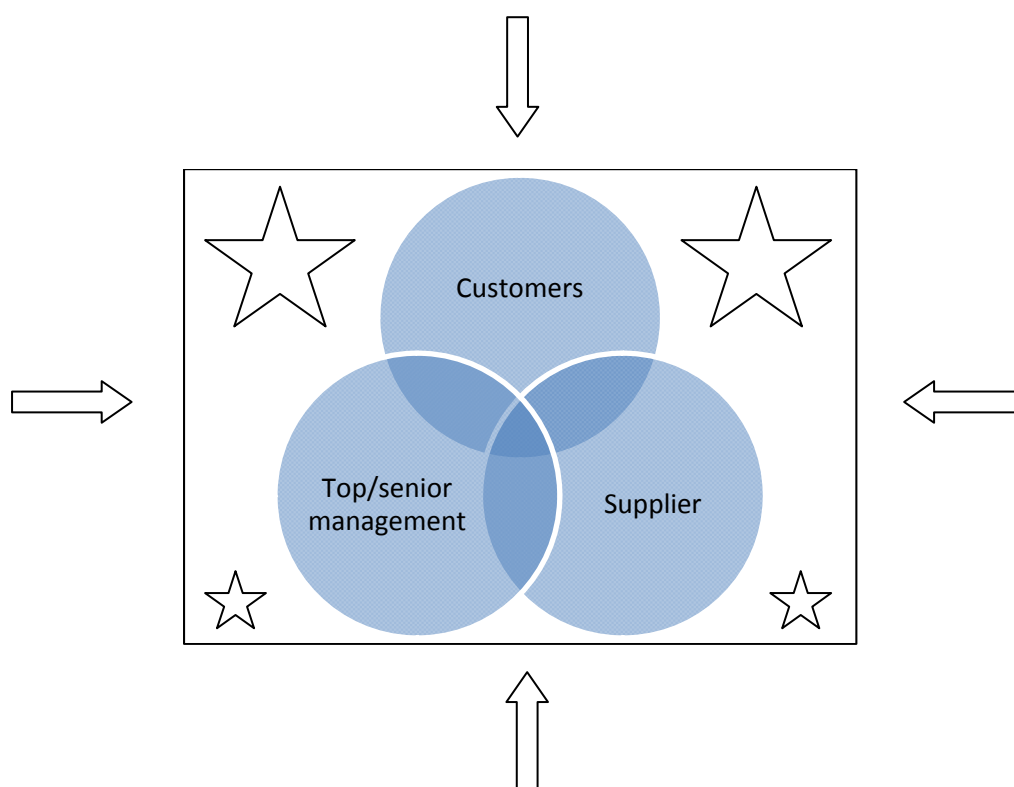


Figure 8: Influencing factors on the success of NPD

As depicted in Figure 8, at the core of successful NPD are the internal success factors which are customers, top management and suppliers. Within the black frame we see factors, depicted as stars, within the organizations environment like cross-functional teams, entrepreneurial climate, and firm structures. The frame symbolizes the border between internal and the

external factors as for example market newness, industry life-cycle, and a fast-moving technology frontier, which are illustrated as arrows.

2.4 The role of obligation books

The use of a functional specification document³ as well as a requirement specification⁴ is a particularity in the German-speaking area and has become common practice in central Europe as well over the last decades. As the Pro4Plast project uses the term “obligation book” as a literal translation for the term “Pflichtenheft”, this thesis will stick to this term as well.

The requirement specification contains the needs and requirements from the customer side. They are translated from a user-oriented language into an engineering-oriented language. They are usually generated by the marketing department.

The obligation book is at the center of the PDP in most product development processes. As depicted in Figure 9, its creation ends the predevelopment phase and triggers the actual development process. It contains contractually binding goals of the development process of innovation projects. The obligation book documents all material requirements (technical, production, financial, etc.) a NPD project has to fulfill. It describes in detail which problems have to be solved and which goals have to be met. Moreover, the financial framework and deadlines are outlined. It is based on market research and/or recommendations from customers. According to Verworn and Herstatt (2002), nearly every German company in industry sectors in which engineering plays a major role, uses obligation books. The creation of obligation books usually takes place at the R&D department.

³ German equivalent: Pflichtenheft

⁴ German equivalent: Lastenheft

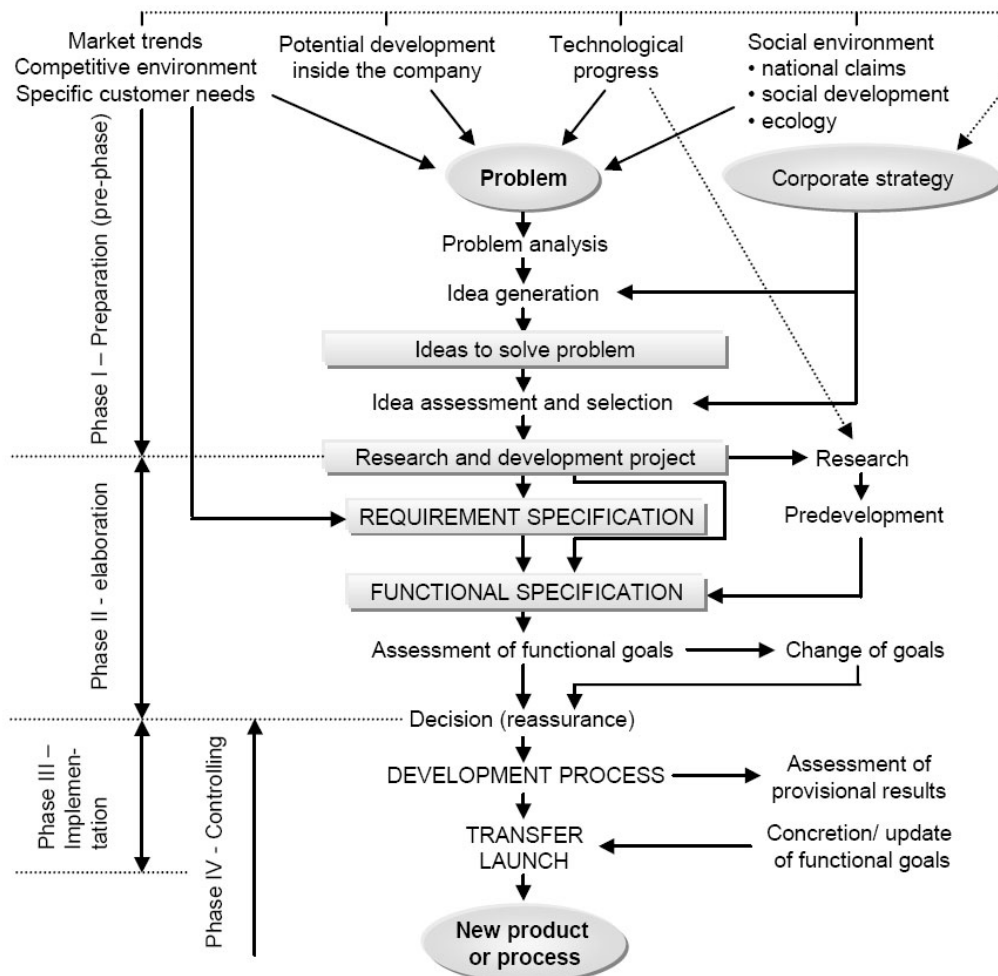


Figure 9: Process model including requirement specification and functional specification/obligation book
(source: Verworn and Herstatt, 2002, p.13)

2.5 Characteristics of PDP within the injection molding industry

Before this point, the discussion was not related to the specific context of the injection molding industry. We have been covering the general process in literature without connections to the NPD in this field. The remainder of the thesis is therefore focused on the tasks a NPDP in the injection molding industry provides.

For thermoplastic polymers the process of injection molding is predominantly used. The thermoplastic material is heated until it melts, then is forced into a steel mold, where it cools and solidifies. With injection molding one can generate complex product structures with

reduced part counts. Boothroyd et al. (2002) cite as an example the progress in development which helped IBM simplify their printer products by using molded parts which rendered possible to reduce part count from 152 to 32 and therefore reduce assembly time from 30 to 3 minutes. In injection molding, the tooling and equipment utilized is expensive, therefore it is vital to be able to obtain part and tooling cost estimates at the earliest stages of design. This helps making the right choice of and obtaining maximum economic advantage from the process. The design and construction of the mold is the economically deciding factor in injection molding. Therefore, mold design usually takes place in isolation from the various other functions involved. This impedes the exchange of ideas and more generally of information between the tool maker and molder on one side, and the part designer on the other. It occurs frequently that only after major investments in tooling and testing have already been made, desirable changes in part design become evident. This belated recognition can provide significant ramifications in terms of final cost and part quality. In contrast, mold cost estimations which are made during the concept design stage itself will help in identifying acceptable part and mold configurations before actual investment in the mold is made.

There are two major categories which make up the cost of the mold: (1) the cost of the prefabricated mold base consisting of the required plates, pillars, guide bushings etc., and (2) cavity and core fabrication costs (Boothroyd et al., 2002).

Chen and Liu (1999) differentiate between the following four stages in the conventional injection molding PDP: (1) product design, (2) process design, (3) mold design, (4) manufacturing planning.

(1) is divided into 3 steps: conceptional design based on product requirements; preliminary design, product geometry and specifications of additional performance requirements; and detailed design which represents a shift of the preliminary design that is functionally acceptable and compatible with the injection molding process.

Stage (2) consists of the definition of molding process parameters like heating temperature, compression, and injection speed.

(3) includes the determination of shrinkage, cavity, and core design, as well as parting, cooling and ejection venting.

Step (4) contains the determination of detailed planning of the production process of mold manufacturing.

3 Method of evaluation

This chapter discusses arguments for qualitative research in general, followed by a detailed description and justification of the case study approach, which we chose to tackle our research questions.

3.1 Qualitative research

Qualitative research uses small sample sizes which are studied in-depth, unlike quantitative research, which aims for larger number of context-stripped cases in order to reach statistical significance. Though it is argued that qualitative studies often explore a new area of research and build a theory about it, it can also be used to confirm or test an existing theory (Miles and Huberman, 1994).

Most qualitative research examines one single case which they define as a “*phenomenon embedded in a single social setting*” (Miles and Hubermann, 1994, p.27). This case is the unit of analysis. Qualitative research has to be in intense and/or prolonged contact with a life situation. These situations should be reflective of the everyday life of organizations. The researcher should gain a good overview of the context: its logic, arrangements, explicit and implicit rules. These insights should provide material which can be interpreted in many different ways. The researcher’s task is to find an interpretation based on theoretical explanations or internal consistency (Miles and Hubermann, 1994). However, this distinction between qualitative and quantitative data and research does not imply that they cannot be combined. Arguments for linking qualitative and quantitative data are (Miles and Huberman, 1994): (1) to enable confirmation or corroboration of each other via triangulation, (2) to elaborate or develop analysis, and (3) to initiate new lines of thinking through attention to surprises or paradoxes.

According to Yin (2009), there are five analytic techniques which can be applied when doing case study research: pattern matching, explanation building, time-series analysis, logic models, and cross-case syntheses.

Pattern matching compares an empirically based pattern with a predicted one. If these match, a case for the internal validity can be made.

Explanation building is the definition of a presumed set of causal links about phenomena, mostly by using narratives.

In time-series analysis, the goal is to understand the underlying context of a sequence of data points. It tries to explain where these data-points come from, what generated them, and which patterns they will follow in the near future.

The logic models technique stipulates a complex chain of events over an extended period of time. The events are staged in repeated cause-effect-cause-effect patterns, whereby a dependent variable (event) at an earlier stage becomes an independent variable (causal event) for the next stage.

Cross-case synthesis aggregates findings across a series of individual cases or studies. With a large number of cases or studies available, it can even incorporate quantitative techniques or meta-analyses. In contrast to this last one, the previous four techniques can all be applied even if there is only one case.

Due to the structure of our data, only the first two techniques are applicable to this thesis.

Miles and Huberman (1994), for example, describe a design, in which a questionnaire is developed and used in a quantitative study. The findings of this study are deepened and tested systematically by means of qualitative analysis.

A common and general method to conduct qualitative research is provided by Carney's "ladder of abstraction". At the outset there is a text, in which one tries to identify themes and trends. Then the researcher tests assumptions and findings in order to lay out a "deep structure". Finally the data is integrated into an explanatory framework. The data therefore is transformed by condensing, clustering, sorting and linking information over time (Miles and Huberman, 1994).

However, it is often very difficult to draw a line between describing and explaining in the course of a case study. More and more data is condensed into a more and more coherent understanding of what, how and why (Miles and Huberman, 1994). Furthermore, the validity of explanations is limited as explanations are *"always open; they depend on certain conditions and are partial, approximate, indeterminate in application to specific cases, inconclusive, uncertain, and typically limited to specific contexts"* (Miles and Huberman, 1994, p. 144). The challenge for good explanations, as Miles and Huberman (1994) see it, is to link the explanations given by the participants of a study to the ones a researcher develops.

3.2 Case study approach

As mentioned above, the case – as a phenomenon embedded in its social setting – is the unit of analysis, and the case study approach the most frequently used in qualitative research.

According to Yin (2009) a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between the phenomenon and its context are not clearly evident. This is an extension of Eisenhardt's (1989) view, that case study research is a research strategy, which seeks to understand the dynamics present within distinct settings.

Benbasat et al. (1987) define 11 key characteristics of case studies:

- 1) A phenomenon is examined in a natural setting.
- 2) Data is collected by multiple means.
- 3) One or few entities (person, group, or organization) are examined.
- 4) The complexity of the unit is studied intensively.
- 5) Case studies are more suitable for the exploration, classification and hypotheses development stages of the knowledge building process; the investigator should have a receptive attitude towards exploration.
- 6) No experimental controls or manipulation are involved.
- 7) The investigator may not specify the set of independent and dependent variables in advance.
- 8) The results derived depend heavily on the integrative powers of the investigator.
- 9) Changes in site selection and data collection methods could take place as the investigator develops new hypotheses.
- 10) Case research is useful in the study of “why” and “how” questions because these deal with operational links to be traced over time rather than with frequency or incidence.
- 11) The focus is on contemporary events.

Note, that depending on the research questions to address, several alternative research designs are thinkable (Yin, 2009), as illustrated in Figure 10.

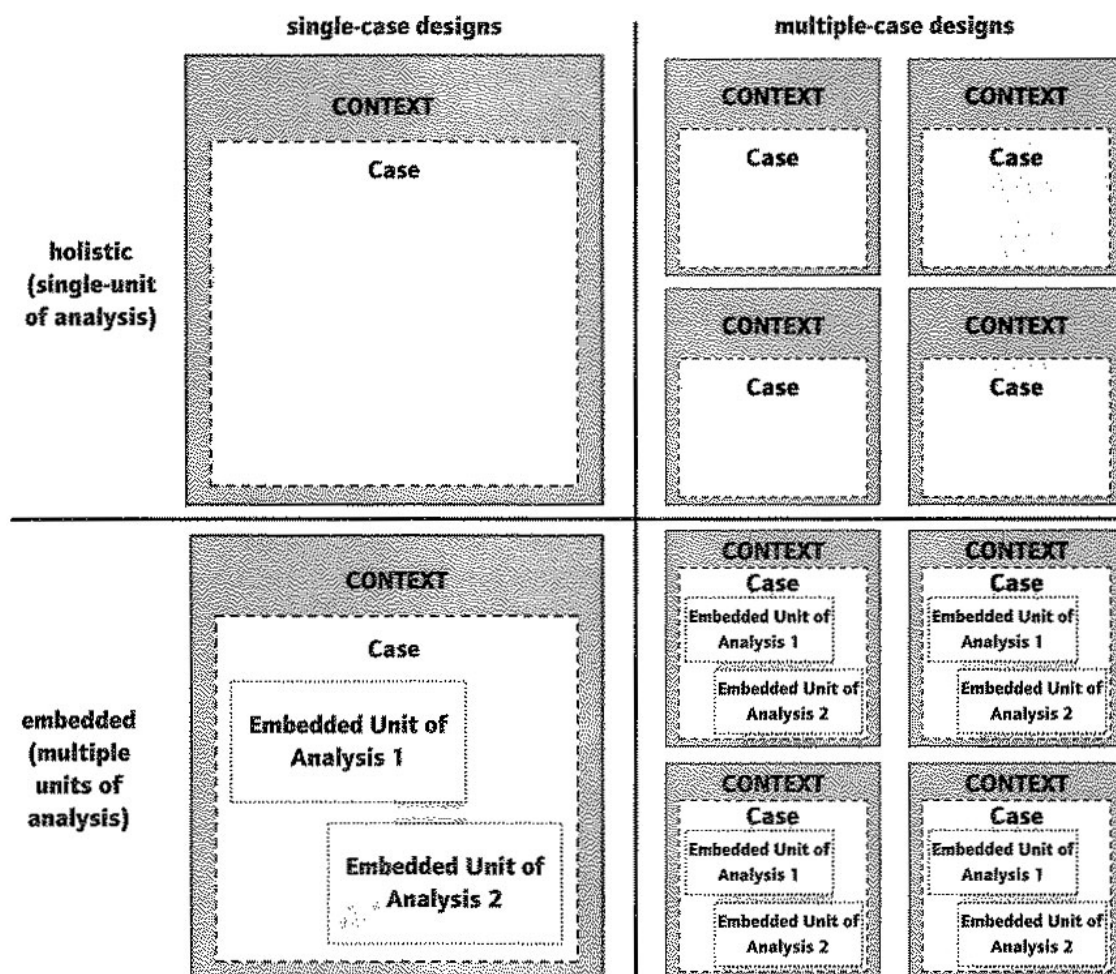


Figure 10: Basic types of designs for case studies (source: Yin, 2009, p.46)

Yin (2009) distinguishes four types of design for case studies, structured in a 2×2 matrix (see Figure 10). In this matrix, the borders between the case and its context, as discussed above, as a constituting feature of cases are not likely to be sharp, which is indicated by the dotted lines. According to Yin (2009), the characterization of case study approaches bases on two factors: (1) the number of units per case (single vs. multi unit cases) and (2) the number of cases per study (single and multiple case design).

The resulting 4 types of designs are: (1) holistic single case study (an indepth analysis of one single unit case), (2) embedded single case study (bases analysis on the results from multiple units within the same context), (3) holistic multiple case study (several cases are studied in their specific and distinct context) and (4) embedded multiple case study (several cases units of analysis are studied in different cases within their specific contexts). As an example for multiple case designs, Yin (2009) discusses school innovation projects, in which each school adopts an innovation. One could now put the focus for a case study on each individual school, but the study as a whole covers several schools, which he defines as multiple-case design.

As an advantage of multiple-case designs over single ones, Yin (2009) argues that the evidence from multiple cases is often considered more compelling, as they make results much more robust. As a disadvantage, Yin (2009) sees the grand effort necessary for this kind of design.

Despite the different design alternatives, there are some general guidelines how case study research can be conducted.

Although we do not look at theory development but case study methodology in general – so that some phases are obsolete – Eisenhardt (1989) provides a good overview of the phases of case study research.

Step	Activity	Reason
Getting Started	Definition of research question Possibly a priori constructs Neither theory nor hypotheses	Focuses efforts Provides better grounding of construct measures Retains theoretical flexibility
Selecting Cases	Specified population Theoretical, not random, sampling	Constrains extraneous variation and sharpens external validity Focuses efforts on theoretically useful cases – i.e., those that replicate or extend theory by filling conceptual categories

Crafting Instruments and Protocols	Multiple data collection methods Qualitative and quantitative data combined Multiple investigators	Strengthens grounding of theory by triangulation of evidence Synergistic view of evidence Fosters divergent perspectives and strengthens grounding
Entering the Field	Overlap data collection and analysis, including field notes Flexible and opportunistic data collection methods	Speeds analyses and reveals helpful adjustments to data collection Allows investigators to take advantage of emergent themes and unique case features
Analyzing Data	Within-case analysis: Describing and explaining	Gains familiarity with data and preliminary theory generation

Table 1: Process of building theory from case study research (adapted from Eisenhardt, 1989, p.533)

To get started, Eisenhardt (1989) underlines that the definition of a research question is vital in case study research. Without a focus, Eisenhardt (1989) argues, one gets easily lost in the amount of data gathered.

Eisenhardt (1989) also sees the necessity for specifying constructs in this stage. She argues that the empirical grounding for the emergent theory grows firmer with this step. During research, however, the research question may shift and the construct may have no place in the resultant theory, even if the measuring is very good. Eisenhardt (1989) cites examples of researchers overturning their research strategies after serendipitous findings. There, the focus of research emerged after the collection of data had begun. To sum up, it is good to have construct theories in mind but with the data one should be ready to give them up.

Eisenhardt (1989) considers the selection of cases as the next important step towards good case study research. Despite for theory building, it is good to generate precise statistical

evidence on the distribution of variables within the population, other sampling methods are suggested in literature.

The next consideration Eisenhardt (1989) states is dealing with the crafting of instruments and protocols. She makes a case for the use of multiple data collection methods. The range is from interviews and observations to archival sources. The more data sources are available, the stronger is the effect through triangulation. A consideration here is to include qualitative data only, quantitative data only or both. At this point, Eisenhardt (1989) also makes a case for multiple investigators, as they increase the likelihood of generating new insights which may be in the data as well as confirm or object previous findings and through this increase the reliability of the study.

Eisenhardt (1989) suggests taking field notes as a kind of diary when conducting research. This happens in the phase she calls “entering the field”. The point in doing so is to generate an overlap of data analysis and data collection. It equips the researcher with a flexibility towards an otherwise closed set of data.

Eisenhardt (1989) points out that the most important step is to analyze within-case data. The challenge here is to find a mix of appropriate methods to do so. Eisenhardt (1989) describes various approaches that led to good analysis of vast amounts of data. But the point she makes is that a researcher has to find a way to become familiar with each case as a stand-alone identity in order to be able to identify its unique patterns.

3.3 Chosen method

The limited possibilities for us to get insight into this subject had a large influence on the conception of our methodology. It was, for example, unclear in the beginning if we would get the cumulated answers of the questionnaires which were already generated by the steering committee or if we had to analyze the data ourselves. Therefore we began to analyze the questionnaire’s structure thoroughly.

Our study relied primarily on a data-driven qualitative approach. We chose the case study method as it enabled us to examine the process and consequences of the development of new products. It allowed us to present the perspectives of enterprises within the injection molding industry engaging in such processes and the managerial influences they are exposed to.

As Lawson and Samson (2001) stated, there is no “*accepted comprehensive and systematic framework guiding managers toward successful innovation*” (p. 378). They conclude that the management of innovation or new products may be sector or industry specific; it might even be firm specific according to them. As Brophey (2007) points out differences in opinion between several scholars are not surprising, given the repeated occurrence of similar high-level findings sometimes contradicted by findings related to different industry contexts. Brophey (2007) suffered, as he states, first-hand from the consequences of these uncertainties as an innovation manager throughout the 1980s and 1990s. Many similarities are shared between the field of innovation management and the one of NPD, and the problem of contradicting literature is one of them. The opinions range from understanding a large part of NPD literature to be “*surprisingly nonconvergent*” (Montoya-Weiss and Calantone, 1994, p. 397) to “*varied and vibrant, yet large and fragmented [...] yet because it has not been tied together to create cogent understanding it is difficult to grasp what is actually known*” (Brown and Eisenhardt, 1995, p. 343-344).

This shortage of unrefuted research in combination with the disagreement about the existence of generic frameworks makes the conventional approach to exploring the theory obsolete. Therefore we decided to engage in an exploratory case study trying to include the current state of literature.

Of the eleven prerequisites Benbasat et al. (1987) specified, nine were fulfilled, one was fulfilled partly and only one remained open:

- 1) The NPDP was examined where it happens: at the organization.
- 2) Data was collected by means of a questionnaire and the assessment of an industry consultant.
- 3) Only one industry sector was examined, namely injection molding.
- 4) The data we were provided with gave us a picture of the complexity of the unit, which we analyzed carefully.
- 5) We conducted an explorative study from which we derived recommendations for the management of such processes.

- 6) As we had no influence on the questionnaire, no manipulations occurred.
- 7) We did not specify in advance which variables we considered independent and which ones dependent.
- 8) Our results are well-documented in literature and we tried to lay out the current state of research.
- 9) This condition is not met, as there was no possibility for us to influence site selection or data collection methods.
- 10) This condition is only met partly, as our study tries to find the answer to “which” managerial factors are essential and “how” they exert influence. Additionally, we had no possibility to trace influences over time.
- 11) This study depicts the current state of NPD.

According to Yin's (2009) typology of case studies, our study is to be classified as an embedded single case study. The context of our case is the injection molding industry. The case itself is the NPD in this sector and the embedded units of analysis are the organizations participating.

4 Data

This chapter discusses the data used to generate the case study, especially information from the Pro4Plast project. The questionnaire used in a survey among participants in this project – with the aim to investigate currently implemented NPDP - is explained.

4.1 Questionnaire

The questionnaire which the partner companies in this project were asked to complete had been developed by the Pro4Plast steering committee and consisted of 5 parts (Q1 to Q5). As Q2, Q4 and Q5 are about technical details, we were only provided with the results of Q1 and Q3.

Q1 deals with general information regarding the experiences of the company with simulation technology. It provided us with a picture about whether simulation techniques were applied, which experiences were gathered during product development processes and which position in the “added value chain” the company took.

The data collected by Q3 is the main focus of this thesis. This questionnaire is divided into three sections: new product development process, obligation books and cooperation with partners. The questionnaire Q3 is printed in the Appendix.

4.1.1 Section “New product development process”

This section asks whether there is a defined PDP and what it does define. Next, a description of the process is to be given and the tools to manage the process are asked for. The involved departments at the company as well as at the partner are inquired. The last point asks for the strengths and weaknesses of the process. Here three dimensions are proposed: flexibility, practical follow ability, and the ability to shorten the duration of product development. The

answers to this question we identified as our first success factor and correlated all other answers with it.

4.1.2 Section “Obligation books”

Here, first the existence of obligation books (OB) is asked, and if yes, information about content/structure of the OB, who is involved at the company as well as at the partner and again about strengths and weaknesses, is questioned. The latter point we again identified as success factor against which all other inputs are measured.

4.1.3 Section “Cooperation with partners”

This part consists of open questions about the relationship between OEM and SME. It consists mostly of questions which begin with “how” or “why”, so there is a broad spectrum of answers from which only a few categories could be built. That is why we used the answers to these questions rather as a guideline about the current successes and problems than as empirical results.

4.2 Sampling

Our sample is the entire population of participating companies as all project participants did participate in the survey. Furthermore the Pro4Plast steering committee was able to achieve a 100% response rate among SMEs and OEMs which were part of the project. In addition to that, the five federations of plastic industries of Poland, Slovakia, Hungary, Slovenia and Croatia were also participating. As the returned questionnaires of these federations for one thing were nearly identical and for another thing yielded little insight into PDPs, they were phased out. This means that we have data from 46 questionnaires.

5 Results

In this chapter we first focus on descriptive analysis of the results and then move on to an exploratory analysis in which we identify success and influencing factors on NPD in the injection molding industry.

5.1 Descriptive data analysis

The first question addressed the existence of a predefined PDP. The majority (91%) has such a process. This is a significant difference from the results of a PDMA study which found that 38.5% of US firms use no formal process for managing NPD (Griffin, 1997). This might be caused by the time difference of 10 years as well as by the differences in PD approaches between companies in Europe and in the US.

The distribution of specific process models according to the answers to question 2 is depicted in Figure 11. The vast majority of these 42 enterprises are using ISO (71%) or ISO-oriented (7%) processes followed by Stage Gate processes (17%). The remaining were firm-specific internal processes not oriented towards the above models. These results are in contrast to Griffin's (1996) findings that nearly 60 percent of US firms used a cross-functional Stage Gate development process for NPD.

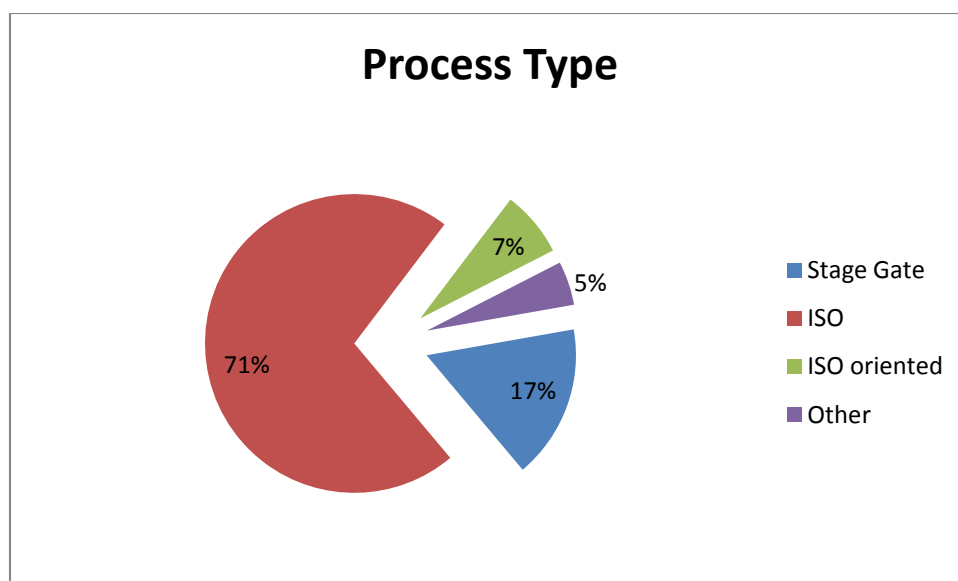


Figure 11: Types of PDP used

Only 5 of the respondents provided a process model as requested in question 3, which however are not discussed in detail in this thesis for secrecy reasons.

To manage the above discussed processes, a set of tools are applied (alone or in combination) among which the most prominent is MS Excel, followed by project management (PM) software and enterprise resource planning (ERP) systems. Other tools mentioned include CAQ, Navision, or simple drawings.

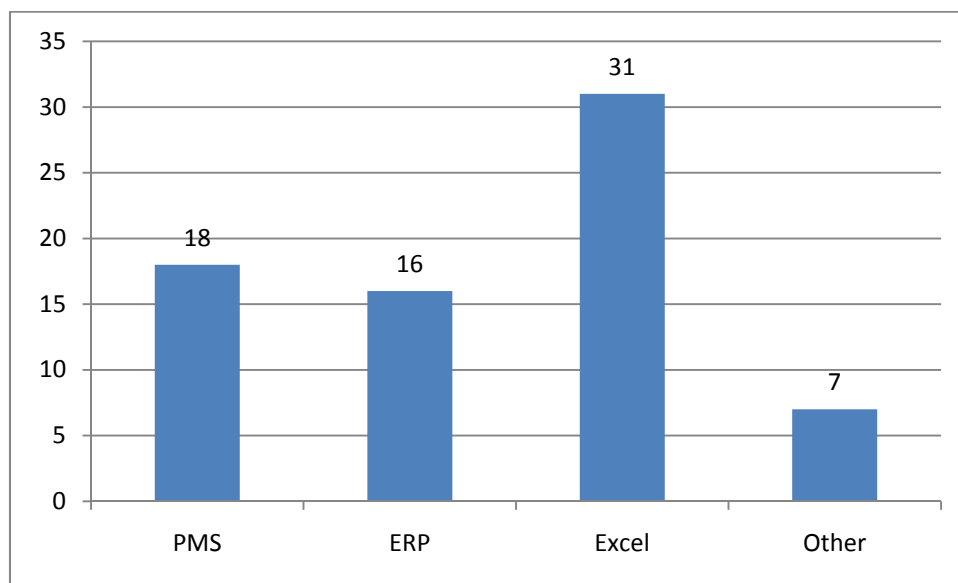


Figure 12: Usage of software tools for PDP (N=46, multiple answers possible)

The units involved in the PDP (question 5) are shown in Figure 13. Research and development obviously is involved in every company⁵, which contrasts the result of Griffin (1997). She found that in her sample of 143 organizations, it is equally likely for marketing, R&D and production to be involved in the PDP.

⁵ One respondent did not answer question 4.

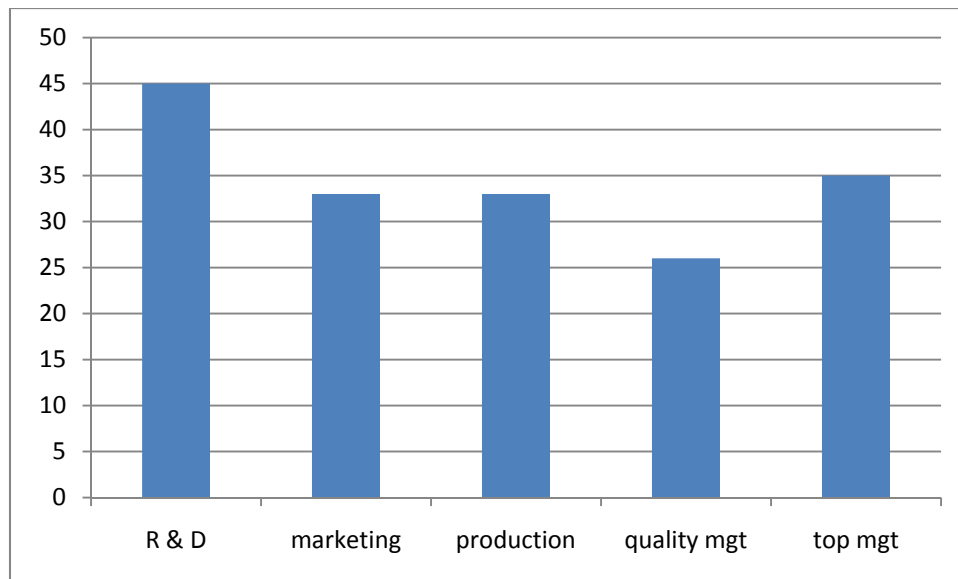


Figure 13: Departments involved in PDP (N= 46, multiple answers possible)

As the department most involved, 61% of respondents mentioned R&D, followed by top management (31%), while other departments like marketing and production were rarely mentioned – two (5%) and one time (2%) respectively.

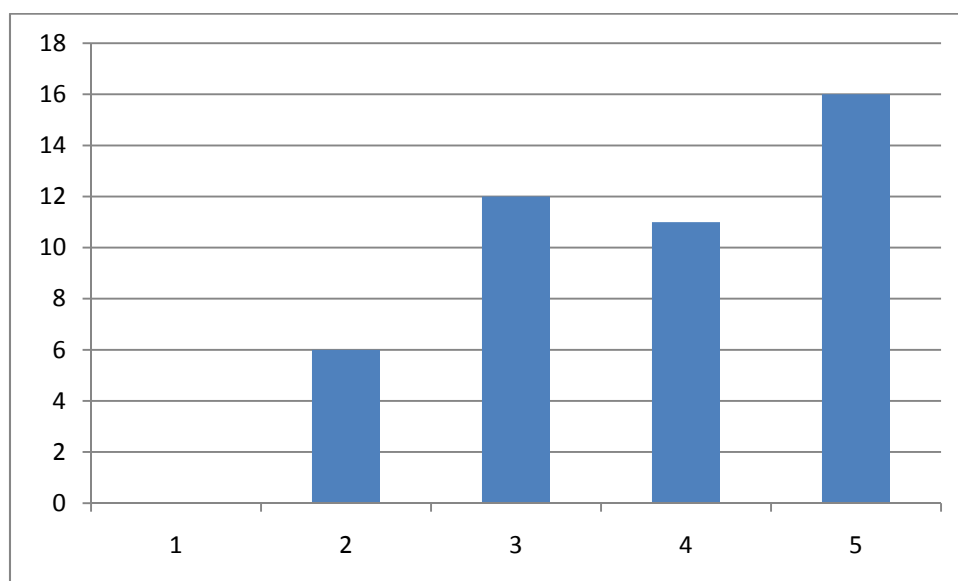


Figure 14: Number of departments involved in PDP

As multiple answers are possible, we were interested in how many and which combinations of departments were involved in the PDP. Our findings are summarized in Figure 14. Interestingly, in none of the respondents PDPs, only one department is involved. In the vast majority of enterprises, at least three departments are involved (which are R&D, top management with either marketing or production or both).

From the side of the customer, 76% of the respondents see flexibility and practical applicability of their PDP as strength. On the other hand, the duration of the PDP is in general regarded as weakness. Only 35% indicate that their PDP shortens the time for PD.

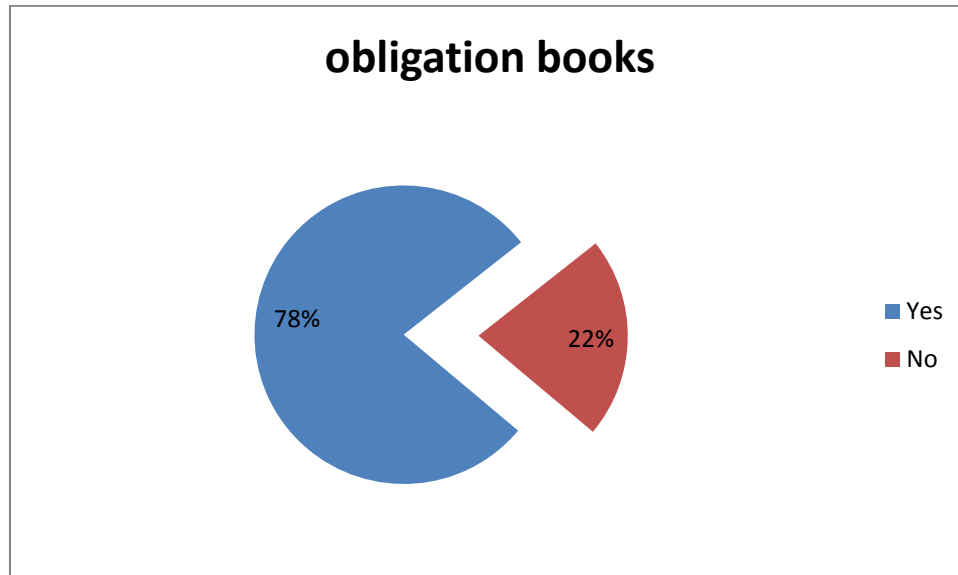


Figure 15: The use of obligation books

The majority of companies use obligation books in PD, according to question 8 (see Figure 15). In 81% of the cases, these obligation books contain information about material requirements, whereas only 41% of the respondents' books explain the production process.

Question 10, the results of which are depicted in Figure 16, addressed the issue of which departments of the focal enterprise but also of the customer enterprise are involved in the development of obligation books. Procurement only participates on the customer's side. Generally speaking, if production or marketing/sales is involved then only on the side of the focal company. R&D is always present, in few cases only from the focal company, much more often on both sides. By contrast, in most cases top management is not involved, and if it is, then only on the side of the focal company and in rare cases on both.

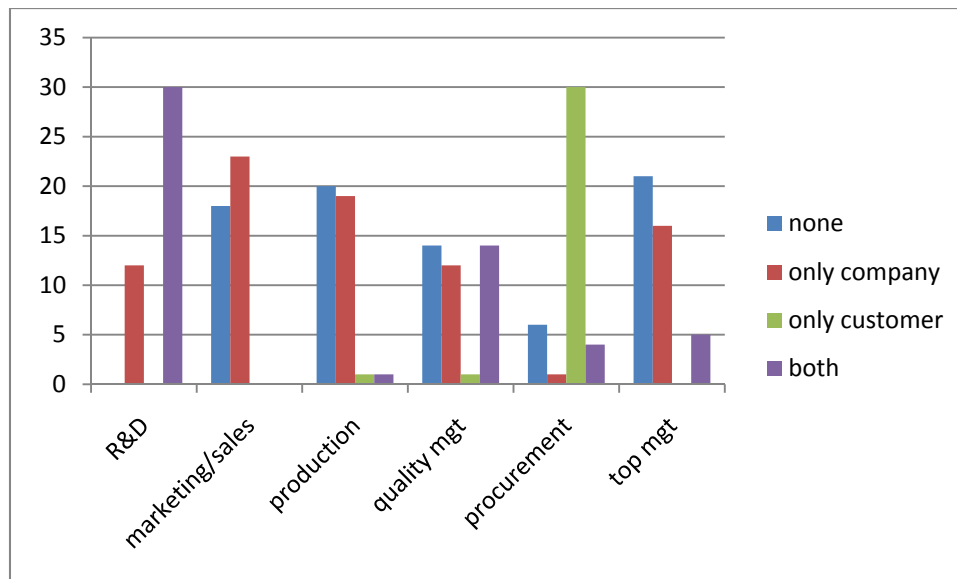


Figure 16: Departments involved in development of obligation books on both sides of the partnership

The strengths of obligation books are the subject of question 11. 76% see their obligation books as flexible enough and another 78% see the practical applicability of obligation books as strengths. However, only 35% recognize a shortening of PD time through their obligation books. Although the results to this question seem nearly the same as the ones to question 7, the companies answered these two questions quite differently. 10 companies judged the flexibility of PDP and of the obligation books differently, 13 the applicability. Another 10 companies gave different answers to the questions of the process respectively the obligation books shortening the PDP.

None of the respondents assessed their obligation books as too detailed, whereas 41% deem them containing not enough information. 52% are content with their obligation books, 7% did not answer this question.

The evaluation of the partnership is detailed in Figure 17. Although the arithmetic mean is 2.67, the data distribution is rather U-shaped. The majority of the respondents see a rather one-sided domination of the cooperation. A considerable number, however, judge it to be a cooperation of equals.

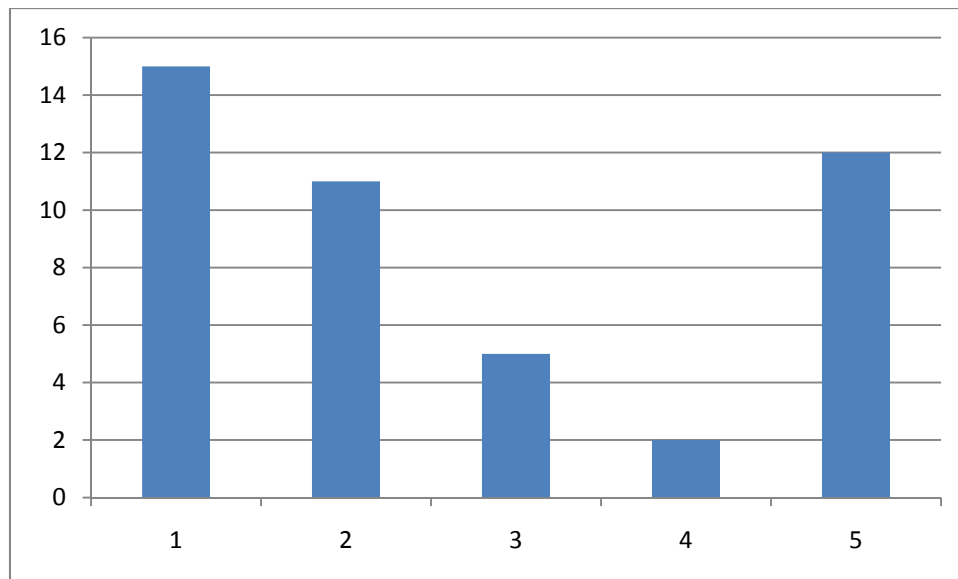


Figure 17: Evaluation of the cooperation. Five-point Likert scale, dominated by one (1) to cooperation of equals (5)

93% of participating companies answered that a jointly developed PDP could improve the cooperation between partners, though only 50% identify their partner's willingness to change their organizational structures.

Question 17 treated the possibilities of negative consequences on future orders resulting from a closer cooperation between partners. Only 34% of respondents saw this as a possibility. More than half of the companies noted that separate contracts would eliminate this danger.

Among reasons for the lacking willingness of OEMs to form PD-cooperations with their suppliers, asked for in question 18, differences in knowledge, process or structure are the responses which came most often (20% each), followed by the fear of dependency (17%), trust related issues (15%), and knowhow drain (13%).

The vast majority of answer fields of question 19 were left blank, as participants did not consider themselves capable of providing suggestions on how to improve the existing Pro4Plast NPDP concept at this point in time.

All except one respondent (98%) endorsed the proposition in question 20 that material and tooling experts of the supplier should be involved during the development of the obligation book. A majority of 72% also found that the same is true regarding external experts.

The final question is detailed in Figure 18. Most respondents (63%) found the PDP to be very important, whereas only one saw it as unimportant.

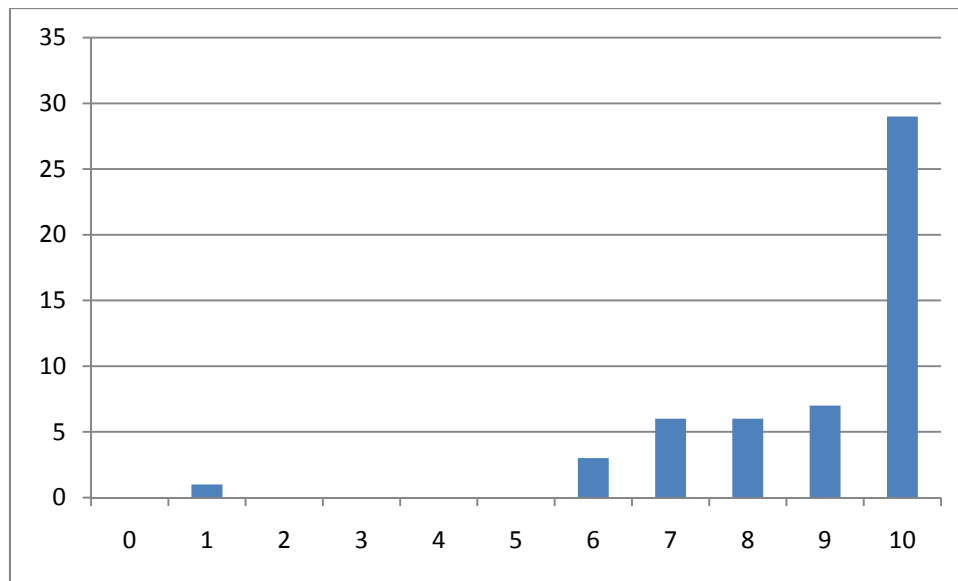


Figure 18: Importance of PDP (Likert scale , 0=not important, 10=very important)

5.2 Success factors

In order to relate the above results to each other we first identified success factors, which to us are the results of questions seven and eleven, respectively. The next step was to look into what influenced these factors significantly. The following presents an insight into our most robust findings according to an explorative study we conducted. The goal of this study was to bring to light all the connections between success factors and design parameters. In the following only results are presented which we found to be strongly related.

5.2.1 Top management involvement

The first results had broad implications for an optimized new product development process. It is common knowledge that the influence of top management on PDPs is large (e.g. Montoya-Weiss and Calantone, 1994; Cooper and Kleinschmidt, 1995; Spivey et al., 1997; Poolton and Barclay, 1998; Lynn et al., 1999; Afonso et al., 2008). Brown and Eisenhardt (1995) even see the management factor as the single most influential one, as Figure 6 shows.

Our study does reflect the importance of top management to the process which shows in the following results.

Table 2 shows the relationship between the involvement in the conception of the obligation books of top management on both sides (the OEM and the SME) and the inability of following the PDP easily in practice.

			top management			Total
			none	only company	both	
easily followed PD	can	Count	17	14	1	32
		% within easily followed PD	53,1%	43,8%	3,1%	100,0%
		% within top management	81,0%	87,5%	20,0%	76,2%
		% of Total	40,5%	33,3%	2,4%	76,2%
		Std. Residual	,3	,5	-1,4	
	cannot	Count	4	2	4	10
		% within easily followed PD	40,0%	20,0%	40,0%	100,0%
		% within top management	19,0%	12,5%	80,0%	23,8%
		% of Total	9,5%	4,8%	9,5%	23,8%
		Std. Residual	-,4	-,9	2,6	
Total	Count		21	16	5	42
	% within easily followed PD		50,0%	38,1%	11,9%	100,0%
	% within top management		100,0%	100,0%	100,0%	100,0%
	% of Total		50,0%	38,1%	11,9%	100,0%

Table 2: Relationship between the involvement in the conception of obligation books of top management and the easiness of following the process in practice ($\chi^2=10.093$, $p<0.01$).

This means that if top management is involved at the OEMs side as well as on the SME side, the NPDP is becoming unpractical.

Our findings also show that the same strong relationship exists between the inflexibility of the PDP and the involvement of top management on both sides. This leads to the assumption that top management has a strong influence on the success of the adaptation of the PDP process to the needs of the market. Whenever it is involved on both sides, however, tensions seem to occur.

The same is true when it comes to obligation books. Table 3 shows the influence of top management involvement at the customer/OEM side on the practicability of the obligation

books. Here it can also be seen that a significant number of companies that have to deal with the top management of the other side have difficulties following their obligation books.

			top mgt		Total
			YES	NO	
easily followed	can	Count	4	25	29
OB		% within easily followed OB	13,8%	86,2%	100,0%
		% within top mgt	50,0%	86,2%	78,4%
		% of Total	10,8%	67,6%	78,4%
		Std. Residual	-,9	,5	
	cannot	Count	4	4	8
		% within easily followed OB	50,0%	50,0%	100,0%
		% within top mgt	50,0%	13,8%	21,6%
		% of Total	10,8%	10,8%	21,6%
		Std. Residual	1,7	-,9	
Total		Count	8	29	37
		% within easily followed OB	21,6%	78,4%	100,0%
		% within top mgt	100,0%	100,0%	100,0%
		% of Total	21,6%	78,4%	100,0%

Table 3: Relationship between the involvement of top management in the conception of the PDP process on the customer/OEM side and the easiness of following the obligation books in practice ($\chi^2=4.850$, $p<0.05$).

5.2.2 Quality management involvement

One of our results showed a strong positive relationship between the involvement of a person or a department responsible for quality management and the flexibility of obligation books. As Table 4 shows, companies in which quality management is involved on both sides state that their obligation books are more flexible. Companies which do not involve quality management into the PDP on either side are much more likely to assess inflexibility to their obligation books. Some cells in this table have a case count of less than five. This is problematic when applying a chi-square test, see chapter 6.2 for details.

			quality mgt				Total
			none	only company	only customer	both	
flexibility OB	very flexible	Count	7	8	1	14	30
		% within flexibility OB	23,33	26,67	3,33	46,67	100,00
		% within quality mgt	50,00	66,67	100,00	100,00	73,17
		% of Total	17,07	19,51	2,44	34,15	73,17
		Std. Residual	-1,01	-0,26	0,31	1,17	
	too inflexible	Count	7	4	0	0	11
		% within flexibility OB	63,64	36,36	0,00	0,00	100,00
		% within quality mgt	50,00	33,33	0,00	0,00	26,83
		% of Total	17,07	9,76	0,00	0,00	26,83
		Std. Residual	1,67	0,43	-0,52	-1,94	
Total			14	12	1	14	41
			34,15	29,27	2,44	34,15	100,00
			100,00	100,00	100,00	100,00	100,00
			34,15	29,27	2,44	34,15	100,00

Table 4: Relationship between the involvement of quality management in the conception of the PDP process on the customer/OEM side and the flexibility of obligation books ($\chi^2=9.587$, $p<0.05$).

This corresponds to the results Brown and Eisenhardt (1995) developed in their rational plan model. They found that quality management leads to a fit with market needs and is therefore a key factor to product effectiveness. Boothroyd et al. (1994) focus on the design quality and design costs. They propose to refine the design continuously by measuring parameters like assembly time. They also provide a framework of design guidelines for injection molding in which they develop six specific rules for cost optimization and quality assurance. Ulrich and Eppinger (2004) handle the assurance of quality as one of five priorities in a NPDP. They suggest securing it by means of prototyping.

5.2.3 Quality of obligation books

The positive answer to the question “*Do your obligation books also cover material requirements*” provides a clear indication if companies think that their PDP is increasing PD speed, as can be seen in Table 5. The quality of obligation books is a topic broadly discussed in PM literature. Ruf and Fittkau (2008) underline that a clear structure within NPD processes can only be achieved by the proper use of obligation books. They also state that it speeds up the channels of communication between the instances of such process.

			material		Total
			YES	NO	
shorten duration PD	shortens	Count	14	0	14
		% within shorten duration PD	100,0%	,0%	100,0%
		% within material	41,2%	,0%	33,3%
		% of Total	33,3%	,0%	33,3%
		Std. Residual	,8	-1,6	
	takes too long	Count	20	8	28
		% within shorten duration PD	71,4%	28,6%	100,0%
		% within material	58,8%	100,0%	66,7%
		% of Total	47,6%	19,0%	66,7%
		Std. Residual	-,6	1,2	
Total		Count	34	8	42
		% within shorten duration PD	81,0%	19,0%	100,0%
		% within material	100,0%	100,0%	100,0%
		% of Total	81,0%	19,0%	100,0%

Table 5: Relationship between the existence of material requirements specifications in obligation books and the shortening of the duration of the PDP ($\chi^2=4.941$, $p<0.05$).

Another topic of discussion in literature is the completeness of obligation books. While Ruf and Fittkau (2008) argue that obligation books need to contain as much detailed information as possible in order to reduce uncertainty, Herstatt and Verworn (2007) claim that reducing the information obligation books contain causes a certain degree of flexibility which leads to better results when it comes to reducing development time. They found that often at the time obligation books are designed not all parameters are known in advance. In order not to produce the need for renegotiations – as an OB usually is part of the contract – which in the worst case would cause a halt in the development process, their advice is to leave out certain details deliberately.

Our results show a strong relationship between the detailed explanation of the production process in OBs and the shortening of the duration of the PDP, as Table 5 illustrates. This could be due to the special characteristics of the industry at hand.

			explain		Total
			YES	NO	
shorten duration PD	shortens	Count	11	2	13
		% within shorten duration PD	84,6%	15,4%	100,0%
		% within explain	64,7%	8,3%	31,7%
		% of Total	26,8%	4,9%	31,7%
		Std. Residual	2,4	-2,0	
	takes too long	Count	6	22	28
		% within shorten duration PD	21,4%	78,6%	100,0%
		% within explain	35,3%	91,7%	68,3%
		% of Total	14,6%	53,7%	68,3%
		Std. Residual	-1,6	1,4	
Total		Count	17	24	41
		% within shorten duration PD	41,5%	58,5%	100,0%
		% within explain	100,0%	100,0%	100,0%
		% of Total	41,5%	58,5%	100,0%

Table 6: Relationship between the explanation of the PDP in obligation books and the shortening of the duration of the PDP ($\chi^2=14.604$, $p<0.01$).

One possible explanation is that the usage of the Stage Gate method implies a technically more advanced approach, which could also mean the deployment of simulation techniques in the company. When simulation is applied, few parameters of the PDP remain unclear. Therefore an OB can contain much more detail than without such technology.

5.2.4 Use of project management software

Rangaswamy and Lilien (1997) studied the application of software tools for NPD. Their results indicate that organizations who have implemented software facilitating the NPD process, like Microsoft Project or Lotus Notes, are realizing significant improvements in productivity.

Our results point into the same direction, as Table 7 shows. Firms which are using PM software to coordinate their PD efforts, find themselves with a significantly shorter duration of their PDP compared to those who do not use it.

			PMS		Total
			YES	NO	
shorten duration PD	shortens	Count	10	5	15
		% within shorten duration PD	66,7%	33,3%	100,0%
		% within PMS	55,6%	20,0%	34,9%
		% of Total	23,3%	11,6%	34,9%
		Std. Residual	1,5	-1,3	
	takes too long	Count	8	20	28
		% within shorten duration PD	28,6%	71,4%	100,0%
		% within PMS	44,4%	80,0%	65,1%
		% of Total	18,6%	46,5%	65,1%
		Std. Residual	-1,1	,9	
Total	Count	18	25	43	
	% within shorten duration PD	41,9%	58,1%	100,0%	
	% within PMS	100,0%	100,0%	100,0%	
	% of Total	41,9%	58,1%	100,0%	

Table 7: Relationship between the use of project management software and the shortening of the PDP ($\chi^2=5.824$, $p<0.05$).

5.2.5 Application of Stage Gate method

			Process Type				Total
			Stage Gate	ISO	ISO oriented	Other	
relevant info OB	includes all relevant info	Count	7	7	2	0	16
		% within relevant info OB	43,8%	43,8%	12,5%	,0%	100,0%
		% within Process Type	100,0%	23,3%	66,7%	,0%	38,1%
		% of Total	16,7%	16,7%	4,8%	,0%	38,1%
		Std. Residual	2,7	-1,3	,8	-,9	
	does not include all relevant info	Count	0	23	1	2	26
		% within relevant info OB	,0%	88,5%	3,8%	7,7%	100,0%
		% within Process Type	,0%	76,7%	33,3%	100,0%	61,9%
		% of Total	,0%	54,8%	2,4%	4,8%	61,9%
		Std. Residual	-2,1	1,0	-,6	,7	
Total	Count	7	30	3	2	42	
	% within relevant info OB	16,7%	71,4%	7,1%	4,8%	100,0%	
	% within Process Type	100,0%	100,0%	100,0%	100,0%	100,0%	
	% of Total	16,7%	71,4%	7,1%	4,8%	100,0%	

Table 8: Relationship between the application of the Stage Gate method and the completeness of obligation books ($\chi^2=16.416$, $p<0.05$)

Our final findings show a direct relationship between the type of PDP applied and the completeness of obligation books. While Stage Gate processes exert a positive influence on

the practicability of obligation books, with ISO oriented processes obligation books do not contain all relevant information. The other cases again show a case count of less than five, see chapter 6.2 for details. For this result no corresponding or contradicting evidence in literature can be found. Nevertheless, this result makes sense as the degree of formalization within an organization as well as its commitment to NPD is reflected in the fact that a Stage Gate approach is used. Additionally, in order for such a system to work, a detailed basis is necessary, which only obligation books can provide.

5.3 *Best practice vs. rest*

Based on our results regarding success factors concerted with the judgment of an industry consultant, we divided our sample in two groups: best practice organizations and others. We took a look at the differences between these two groups in regard to answers to the open questions (15, 18 and 19 in Q3), categorized them and derived suggestions from these recommendations for improving cooperation between OEM and SME.

Asked about general suggestions to improve cooperation between OEM and SME the best case suggest that doing so by improved sharing of know-how would be the best way. For both groups an early consideration of all factors was also essential.

The best cases saw different reasons for lacking willingness of OEMs to form PD-cooperations than the others. The former identified as a main reason the lack of trust on the side of the OEM. In contrast to that the latter identified the unequal distribution of power, as well as the fear of losing one's independence as the main sources of not forming such partnerships.

The best case companies saw the best opportunities of improving the existing Pro4plast NPDP by better understanding it. Both groups agreed that the early involvement in the process also plays a major role in improving it.

6 Discussion

In this chapter we are summarizing the results gained above and put them in a managerial context. From this we derive lessons learned and suggestions on how to improve the NPDPs. Finally, we provide a short outlook for this topic.

6.1 Implications for the management of new product development

Framework

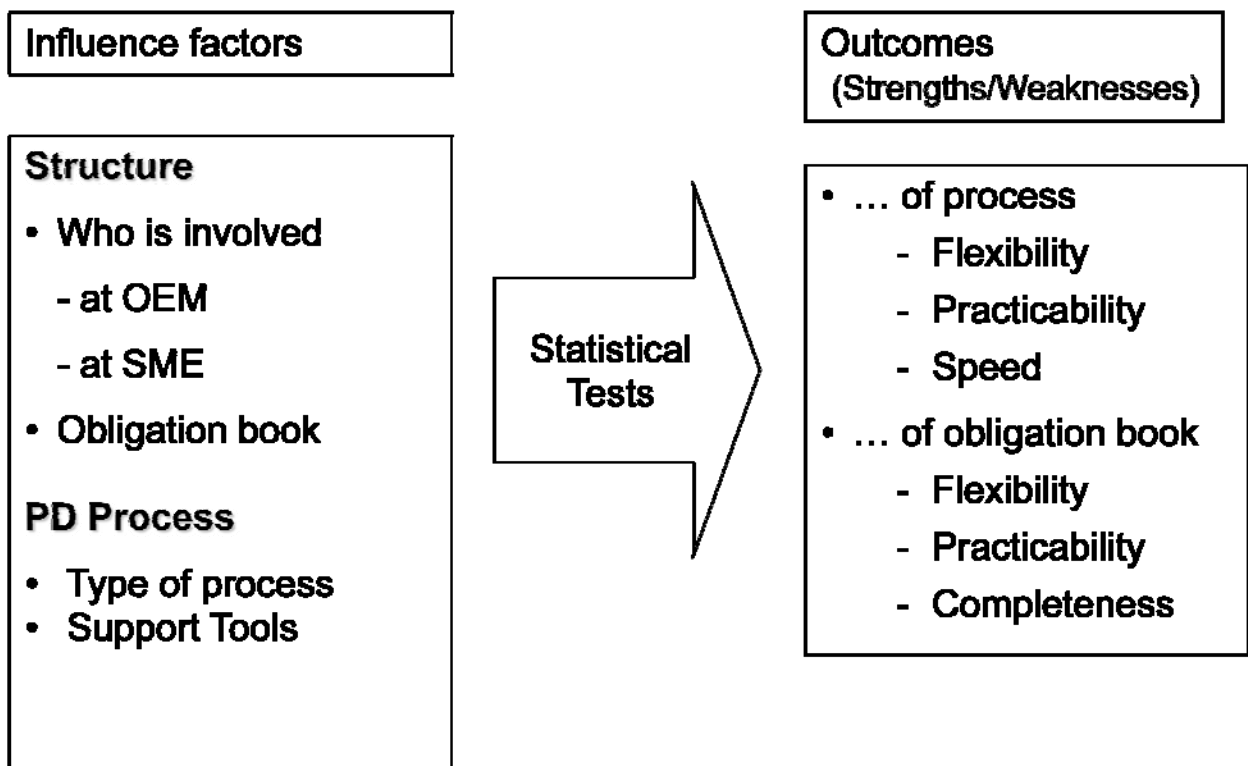


Figure 19: Framework of this study

The framework in Figure 19 shows our field of research. At the right hand side the six success criteria are illustrated which we have defined according to the outcomes of the questionnaires. At the left side we have been taking a look at all factors which possibly influence these outcomes. We then performed a statistical analysis which brought to light the 5 most significant relations between these. According to these results and their interpretation we will identify “lessons learned” which we will list and discuss briefly on the following pages. These

lessons build the basis for the success model we have developed and which we will present subsequently. Then what follows is our interpretation of the different answers to the open questions which the best-practice cases and the others gave.

At the end of this chapter we give a visual and explanatory summary of the lessons learned.

6.1.1 Lessons learned

Lesson 1:

Better manage top management involvement

The involvement and backing of top management is of vital importance to the whole product development process. Our results show, though, that its competencies in strategic leadership are often ineffective on the operative level of planning and executing the development process. Therefore a tendency to “over manage” in the product development phase has to be addressed.

Suggestion:

Set the course and chose the right people but let them do the driving.

Lesson 2:

Get quality management involved

Our findings show that the involvement of quality management has a very positive impact on the flexibility of obligation books. There are three main reasons for this. First, most of the problems in manufacturing arise in the near temporal and geographical surroundings of the cause, while in the context of product development both of these distances are larger Bartezzaghi (1997). The function of quality management is to identify the separations of cause and effect in time and space and to provide solving strategies taking them into account. Second, the learning effects within a project are as valuable as the ones that span to others. The role of quality management is to interpret and enable both forms of learning which leads to an efficient flow of knowledge within the enterprise. Third, quality management puts the focus on the customer and therefore brings in a market orientation which otherwise is missed.

Suggestion:

Quality management helps you ask the right questions.

Lesson 3:

Put the focus on your obligation books

Obligation books are defined as consistent, quantitative target systems which consist of product features and milestones for the development process. Their aim is to plan performance, timelines and costs. Our findings show that obligation books meet these demands as the processes significantly shorten the duration of product development in companies where they are implemented and executed.

Suggestion:

Optimize your obligation books and your PD times will shorten.

Lesson 4:

Project management software helps

Companies which are using PM software are successful in significantly shortening their PD. The reason for this can be found in the structured approach to PD that such software requires. In order to benefit from using it, one has to translate the structure of the projects into the terms of the program. This requires an engagement with and a deep understanding of this structure. Better understanding causes quicker implementation of changes to this structure. PM software also provides scheduling capabilities and the possibility to calculate a critical path if one exists.

Suggestion:

Use PM software to speed your product development.

Lesson 5:

Stage Gate has a very positive influence on obligation books

This is due to the systematic execution of the criteria in obligation books that a Stage Gate processes can provide. Although the concept of a Stage Gate process has been developed in the USA and the idea of obligation books is born in Europe, these two concepts are proved to be a perfect match in terms of planning and reaching certain milestones within a product development project. The awareness of one's own resources and capabilities, specified in the OB, is pre-requisite for the achievement of the gate conditions.

Suggestion:

Use the powerful combination of Stage Gate and obligation book to your advantage.

Lessons from Best Practice:

The following suggestions we derive from our results of chapter 5.3.

- **Work out the problems and differences early**
The earlier concerns are addressed the sooner all parties involved are on the same page. If necessary, start explaining from scratch where differences occur. This is essential for the willingness to share know-how.
- **Build up trust beyond formal contracts**
Have faith in your cooperations, but do not abstain from writing out the integral parts of the contract in full.
- **Have a clear division of competencies and of costs**
In every working partnership rules have to be set and obeyed. Without them the stronger party is in danger of expanding its power beyond allowing the other enough room to breathe.

6.1.2 Visualization and summary of lessons learned

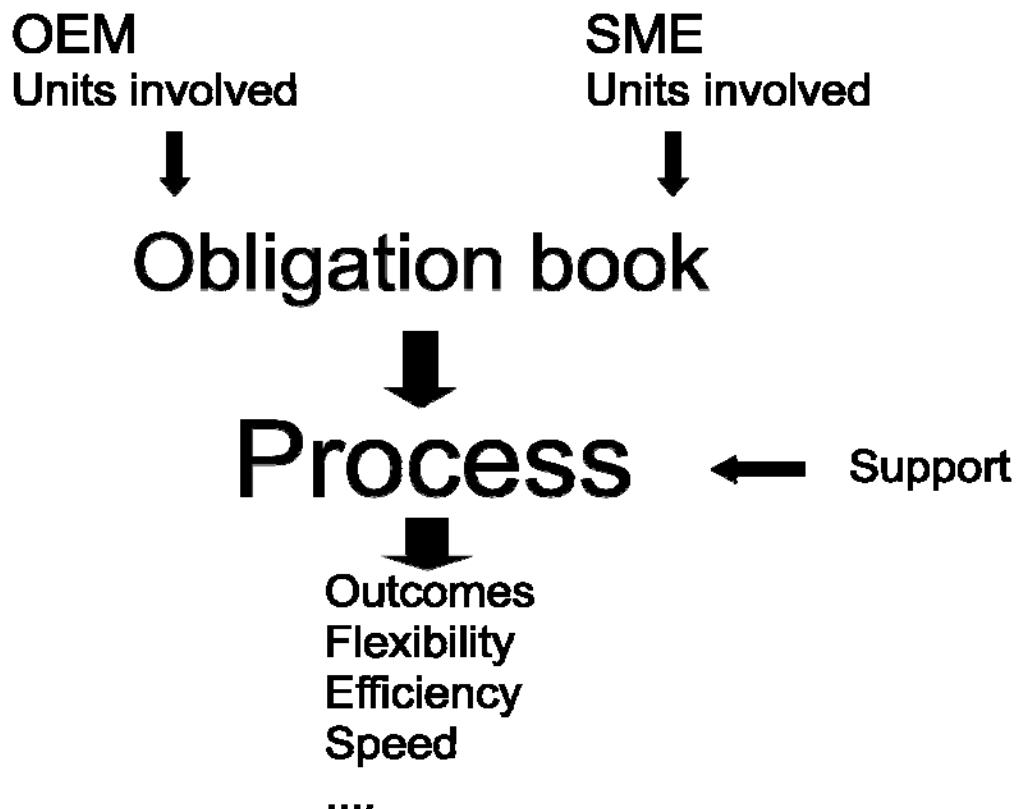


Figure 20: Lessons learned in this study

In order to reap the benefits of an improved product development process and therefore optimize the outcomes in terms of flexibility, efficiency and speed one has to take a look at the influencing factors for such a process. The focus has to lie on the continuous improvement of the process itself. The first question therefore is which kind of process to chose. Our findings show that a Stage Gate process helps the companies which have adopted one to get the information they need into the obligation books which are the most important influencing factor for a successful product development process. Having set the right priorities there has a very positive influence on reaching the overall process goals. Therefore it is essential to also get the right people into the development of an obligation book. We found out that companies for which top management plays a major role in this phase are ending up with a less efficient process. Our findings further show that quality management should be involved here. The final recommendation based on our findings is to use the right support tools like PM software which we identified to contribute strongly to a shortened development process.

6.2 Limitations

At the outset we were provided with the results of a questionnaire which had been developed mainly to collect data on the technical aspects of the NPDPs used by the participating companies. The survey was already in the finishing stages at the time of our start into the project, so we basically started out with the first data coming in.

This initial situation had a large influence on the approach we have chosen. The constraints were twofold. First we were neither involved in the conception nor in the conduction of the survey.

As we had no influence in the design of the questionnaire, the theoretical concepts behind the items have a margin for improvement. The steering committees goal, which the questions are based upon, was to gain insight in existing NPD practices. As they were rather detailed in asking for information on the technical side of the existing PDP, the questions in the sections relevant to this study allowed for a broad spectrum of answers. For example, Question 13 asked for the tasks on which partner companies cooperate and which tasks are done by one party. As there were neither standardized answers nor answer categories to choose from, some

respondents only answered what they were doing their selves, others what their partners were doing. None of the respondents gave examples of what was developed in cooperation.

Therefore we had to categorize some of the answers which left us with an even fewer number of cases in some categories. As the sample size is rather small from the outset, the validity of the results might be limited.

Another limitation concerns our subjective outcome measure – perceived process/OB flexibility, practical follow ability, and the ability to shorten the duration of product development. While for our study there were no objective, hard measure such as new product success available for this industry, future work could use this as the dependent variable.

In addition to that, the specific circumstances of the injection molding industry may limit the usability of these results for other industry branches.

6.3 Outlook

As technological advances render simulation techniques possible which twenty years ago were far out of reach for SMEs, fundamental changes in the planning and execution of NPDP are imminent.

One interesting question which remains unanswered is how the NPDP developed in the Pro4Plast project fares in reality.

Finally, it remains to be seen if the differences in the conception of a NPDP between OEMs and SMEs can be overcome. This study showed, for example, that the perception of the cooperation between OEM and SME varies considerably when it comes to the domination of one party.

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8 Appendix

8.1 Questionnaire⁶

 			
Task-ID:	WP1 T1.1.1.	Topic/Subject:	Pro4Plast -COLL-CT-2006-030205 Q3 : Existing PD-processes and obligation books at coreSME
Subject:	coreSME 10: PKT / A	Date:	6.10.2006

Questionnaire 3 **Section I: Product Development Process**

- Does your company have a defined innovation/product-development process? **NO**
- What does the process define? Roles, milestones, workflow, methods etc.
If applicable: what kind of process is it (QS, ISO, Stage Gate etc.)?
We are in working for ISO-Certification at end end of 2007
- Please describe the process shortly (approx. 3 lines). Please provide a simple drawing / **picture / illustration of the process**.
*Idea from the customer – we check the possibility of making – calculation – prototyping if necessary
Improvement for functionality – construction and toolmaking – production - qualitycheck*
- What kind of tools does your company use to manage the PD-process?
-PMD
-project management software
-other:....*our similar process*
- Which units of your company are involved in this process?
- please name the departments: (for example **R&D, marketing, production**)
- **top management**
Which of these units is involved the most? **Top management**
- Which units at the customer/OEM side is involved in this process?
- **procurement departments**
- RTD-department **purchase department....**
- top-management
- other department(s):
Which of these units is involved the most? **purchase department**

Rev 01	Author: pct-Dr.Altendorfer	www.polyconcent.at	E-mail: altendorfer@polyconcent.at	page 1 from 5
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Task-ID:	WP1 T1.1.1.	Topic/Subject:	Pro4Plast -COLL-CT-2006-030205 Q3 : Existing PD-processes and obligation books at coreSME
Subject:	coreSME 10: PKT / A	Date:	6.10.2006

Questionnaire 3 **Section I: Product Development Process**

- What are the strengths/weaknesses of your PD-process?
Strengths: very flexible
can be followed easily in practice
shortens the duration of product development
other:.... *we are "problem-solver"*
Weaknesses: too inflexible
cannot be followed in practice
takes too long
other:....*no co-working and connection with customer*

Section II: Obligation Books

- Do you have obligation books for each new complex product before development? **Most of all**
- What kind of obligation books are you using?
Please explain the content/structure of your obligation books:
do they only describe the desired functionality of the new part? **YES**
do they also cover material requirements? **Yes, always more**
do they explain the production process? **Yes but too less**
- Who is involved in the development of the obligation books in your company and from customer side?
-please name the involved departments:....
-top-management:....
*In our company: top management, R&D, marketing
From our customer: product department and purchase department, but not enough and less cooperative, they will take no responsibility*

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⁶ We chose to depict a completed questionnaire as we did not receive the raw version of it.

Task-ID:	WP1	Topic/Subject:	Pro4Plast -COLL-CT-2006-030205	Subject:	coreSME 10:	Date:	6.10.2006
	T1.1.1.		Q3 : Existing PD-processes and obligation books at coreSME		PKT / A		

Questionnaire 3

11. What are the strengths/weaknesses of these existing obligation books?

Strengths: very flexible
can be followed easily in practice most of it
shortens the duration of product development
includes many not all relevant information
other:... in the moment the first way to have a process

Weaknesses: too inflexible
cannot be followed in practice
too detailed
does not contain enough information
other:...to less commitment of our customers

12. How would you evaluate the existing obligation books?

too detailed-----just right-----not enough information, but a good starting

Section III: Cooperation between SME and OEM

13. Is there some cooperation between your company and your SME/OEM? Which tasks are covered by both parties in cooperation? Which tasks are done by one party? describe.

Both parties: secrecy, idea, function

Only part of the development-company: who to making, development, (also much of costs)

14. How would you evaluate the cooperation between your company and your SME/your OEM in terms of your common product development?

dominated by

one party-----HERE-----cooperation of equals

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Task-ID:	WP1	Topic/Subject:	Pro4Plast -COLL-CT-2006-030205	Subject:	coreSME 10:	Date:	6.10.2006
	T1.1.1.		Q3 : Existing PD-processes and obligation books at coreSME		PKT / A		

Questionnaire 3

15. Do you think a jointly developed product development process (as suggested in Pro4Plast) could improve the cooperation between OEM and SME? Why, why not? YES

- According to your experiences, do OEMs show willingness to change their organisational structure in order to establish SMEs as "product development partners" on the supplier side? In the last time always more, but it was difficult and depended from the structure of the OEM. For big companies it is self-evident, but smaller OEM's are not able to make this decision.
- Do you think a closer cooperation between OEM and SME in product development can be realised without discrimination regarding future orders? (or does is eliminate competition?)
- YES ?????, but most of time the price is decisived

18. What are the reasons for the lacking willingness of OEMs to form PD-cooperations with their suppliers?

Many people believes, it was a decision only for one and only SME, so they have no chance to compare with other suppliers

19. What are your suggestions on how to improve the existing Pro4Plast „new product development process" concept? I think the idea is good and necessary for th future

20. Who should be involved in the stages of the new process (at the OEM)?

For example material and tooling experts of supplier should be involved during the development of obligation book YES

21. How important is such a process for you?

1 (not important)-----10 (very important)

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8.2 Abstract

This work deals with new product development in the European injection molding industry. In line with the goals of the Pro4Plast project, the aim of this thesis was to evaluate the status quo of new product development. Pro4Plast is a collective research project in cooperation with the European Commission, in which a total of 46 small and medium enterprises as well as original equipment manufacturers took part.

By means of an extensive literature study in combination with the results of a questionnaire developed to evaluate the status quo at the participating companies, this work investigated managerial success factors in new product development within this industry. The focus was on finding factors which influence the reduction of development time as well as the cutting of costs.

We found a system of influencing factors which we divided in internal and external ones. Among the internal factors, we identified three core factors: customers, top management and suppliers. In the organizations' internal environment we found factors like cross-functional teams, entrepreneurial climate, and firm structures. External success factors like market newness, industry life cycles and a fast-moving technology frontier surround the process.

After the analysis of the survey results, we identified seven strong relations between success and influencing factors. Those were:

- The involvement of top management in the conception of the obligation books, which influenced the ability of following the product development process easily in practice.
- The influence of top management involvement at the customer respectively original equipment manufacturer side on the practicability of the obligation books.
- The relationship between the involvement of a person or a department responsible for quality management and the flexibility of obligation books.
- The completeness of obligation books influencing the speed of product development.
- The influence, a detailed explanation of the production process in the obligation book exerts on the shortening of the duration of the product development process.
- The usage of project management software shortening the duration of the product development process.
- The application of the Stage Gate method favoring the practical followability of the obligation books.

We condensed these results into the following five managerial implications:

- Better manage top management involvement.
- Get quality management involved.
- Put the focus on your obligation books.
- Project management software helps.
- Use a Stage Gate process.

We derived the following suggestions of our study of the best practice cases compared to the rest:

- Work out the problems and differences early.
- Build up trust beyond formal contracts.
- Have a clear division of competencies and of costs.

To sum up our findings, in order to reap the benefits of an improved product development process and therefore optimize the outcomes in terms of flexibility, efficiency and speed one has to take a look at the influencing factors for such a process. The focus has to lie on the continuous improvement of the process itself. The first question therefore is which kind of process to chose. Our findings show that a Stage Gate process helps the companies which have adopted one to get the information they need into the obligation books which are the most important influencing factor for a successful product development process. Having set the right priorities there has a very positive influence on reaching the overall process goals. Therefore it is essential to also get the right people into the development of an obligation book. We found out that companies for which top management plays a major role in this phase are ending up with a less efficient process. Our findings further show that quality management should be involved here. The final recommendation based on our findings is to use the right support tools like PM software which we identified to contribute strongly to a shortened development process.

8.3 Zusammenfassung

Die vorliegende Diplomarbeit ergründet die Produktentwicklung in der europäischen Spritzguss-Industrie. Sie orientiert sich in der Fragestellung an den Zielen des Pro4Plast-Projektes, welches den Status Quo der Produktentwicklung untersucht. Pro4Plast ist ein Forschungsprojekt in Kooperation mit der Europäischen Kommission, in welchem insgesamt 46 Klein- und Mittelbetriebe sowie Originalhersteller (OEMs) mitwirkten.

Durch eine umfassende Literaturrecherche in Kombination mit der Auswertung einer Umfrage, welche den Status Quo in den teilnehmenden Unternehmen erhob, erforschte diese Arbeit unternehmerische Erfolgsfaktoren auf dem Gebiet der Neuproduktentwicklung in dieser Industrie. Im Mittelpunkt standen dabei die Verringerung der Entwicklungszeit sowie das Senken der Kosten.

Dabei wurden Einflussfaktoren identifiziert, welche in interne und externe unterteilt wurden. Zu den internen zählen die drei Hauptfaktoren Kunden, Führungskräfte und Lieferanten. Im internen Umfeld des Unternehmens finden sich Faktoren wie das Bilden funktionsübergreifender Arbeitsgruppen, unternehmerisches Klima und Firmenstruktur. Als externe Erfolgsfaktoren sind zum Beispiel die Neuheit des Marktes, die Lebenszyklusphase der Industrie oder sich schnell verändernde Grenzen der Technologie anzusehen.

Nach Analyse der Untersuchungsergebnisse waren folgende sieben Beobachtungen diejenigen mit dem höchsten gemessenen Zusammenhang:

- Das Einbinden der Führungskräfte in die Konzeption des Pflichtenheftes beeinflusste die Fähigkeit, den Entwicklungsprozess einfach in die Praxis umzusetzen, wesentlich.
- Das Einbinden der Führungskräfte beim Kunden bzw. OEM steigerte die Umsetzbarkeit der Pflichtenhefte signifikant.
- Die Flexibilität der Pflichtenhefte wurde durch das Einbeziehen einer Person oder Abteilung, die für Qualitätsmanagement zuständig ist, deutlich verbessert.
- Die Vollständigkeit des Pflichtenhefts stand in engem Zusammenhang mit der Verbesserung der Geschwindigkeit der Produktentwicklung.
- Der Zusammenhang zwischen einer detaillierten Erklärung des Produktionsprozesses im Pflichtenheft und der Verringerung der Dauer des Produktentwicklungsprozesses trat deutlich hervor.
- Der Einsatz von Computerprogrammen für das Projektmanagement verkürzte die Dauer des Entwicklungsprozesses.

- Der Einsatz eines Stage Gate Prozesses wirkte sich positiv auf die praktische Umsetzbarkeit der Pflichtenhefte aus.

Aus diesen Ergebnissen leiteten wir die folgenden fünf Handlungsempfehlungen an das Management ab:

- Besseres Einbinden der Führungskräfte.
- Einbinden des Qualitätsmanagements.
- Die Pflichtenhefte in den Mittelpunkt rücken.
- Einsatz von Computerprogrammen zum Projektmanagement.
- Einsatz des Stage Gate Prozesses.

Drei weitere Empfehlungen leiteten wir aus der Analyse der „Best Practice“-Fälle ab:

- Räumen Sie Probleme und Unterschiede frühzeitig aus.
- Stellen Sie den Aufbau von Vertrauen über die Absicherung durch Verträge.
- Sorgen Sie für eine klare Aufteilung von Kompetenzen und Kosten

Zusammenfassend ist festzustellen, dass für eine Steigerung von Flexibilität, Effizienz und Geschwindigkeit in Produktentwicklungsprozessen, Einflussfaktoren betrachtet werden müssen. Die Frage, welche Art von Entwicklungsprozess gewählt werden soll, steht daher am Beginn. Laut unseren Ergebnissen kann ein Stage Gate Prozess an dieser Stelle empfohlen werden. Dieser unterstützt die Verwendung von Pflichtenheften und sorgt dafür, dass dort die richtigen Informationen zu finden sind. Diese Arbeit konnte nachweisen, dass die korrekte Verwendung von Pflichtenheften großen Einfluss auf Erfolgsfaktoren von Produktentwicklungsprozessen hat. Wurden hier die Weichen richtig gestellt, so kommt man den Zielen eines solchen Prozesses mit großen Schritten näher. Darum ist es von wesentlicher Bedeutung, die Personen und Abteilungen, welche an der Entwicklung von Pflichtenheften mitarbeiten, sorgfältig auszuwählen. Ist der Einfluss der Geschäftsführung hier zu stark, so ist der Produktentwicklungsprozess am Ende weniger effizient. Das Einbeziehen des Qualitätsmanagements jedoch kann an dieser Stelle zu Verbesserungen führen. Am Schluss wird an dieser Stelle der Einsatz von Computerprogrammen für das Projektmanagement empfohlen, welcher den Produktentwicklungsprozess signifikant verkürzt.

Ronald Mitterhofer

Personal Information

Date of Birth: 12.08.1977

Place of Birth: Wels, Austria



Education

March 2009

Vienna University of Technology, Austria

Senior Adviser in e-Nego-motion Project

Focus on the implementation of an electronic negotiation support system

October 1996 – October 2009

Vienna University, Austria

European Master of International Business Studies

Focus on information systems, organizations, and communication

September 1987 – May 1995

Academic High School Anton-Bruckner-Gymnasium, Wels

Focus on languages (English, French, Spanish, Italian, and Latin)
and electronic data processing

September 1983 – July 1987

Primary School Volksschule Gunskirchen, Austria

Work

March 2008 – August 2008

University of Vienna, Austria

Project team member, faculty of business, economics and statistics website
development project

Main responsibility: conception, template testing (Typo3),
interface design, and proofing

September 2007 – March 2008

University of Vienna, Austria

Project assistant, faculty development project TETRIS

Main responsibility: conception, programming and analysis of an
online survey among students with 720 responses

October 2006 – February 2009

University of Vienna, Austria

Teaching Assistant, Prof. Vetschera

Focus on teaching support, grading and organization work

2001 - 2006

UPC Telekabel Wien, Austria

Senior agent at the technical computer support hotline

Troubleshooting of a wide range of IT and internet related problems

August-September 2000

Universität des Saarlandes, Germany

Research assistant, TIME research project, Prof. Scholz

Focus on the investigation of the status quo as well as the perspectives of the telecommunication,
information, media and entertainment industries

October 1995 – May 1996

Fliegerhorst Vogler, Hörsching, Austria

Military service

1993 - 2000

Österreichische Post AG, Gunskirchen

Summer job, mail delivery

Other relevant information

Research interests: human-machine interface, communication

Hobbies: travelling, tennis, soccer, basketball, movies, programming (PHP, MySQL,
javascript, C++)