The fuzzy front end of product development: an exploratory study

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THE "FUZZY FRONT END" OF PRODUCT DEVELOPMENT: AN EXPLORATORY STUDY

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ABSTRACT

The aim of this paper is to describe front-end activities in practice and get first hints for effects of the front end on project outcome and the meaning of contextual factors.

The results of an exploratory study of fourteen product development projects are contrary to the wide-spread opinion that the quality of execution of front-end activities in practice is low. Although, due to the small sample size, our findings are limited, there seems to be an indirect impact of the fuzzy front end on project outcome: Front-end activities may reduce deviations during the following development phase. Furthermore, company size and the degree of newness of a project to a firm seem to have an influence on the fuzzy front end.

Therefore, for future research, we suggest large-scale studies which examines direct and indirect effects and consider contextual factors, e.g., by evaluating structural equation models.

INTRODUCTION

Recently, increased attention has been paid to the fuzzy front end of product development. Managers indicate the front end as the greatest weakness in product innovation [1]. It determines which projects will be executed. Quality, costs, and timings are mostly defined during the front end. At this early stage, the effort to optimize is low and effects on the whole innovation process are high [2].

Consistently, an extensive empirical study showed that "the greatest differences between winners and losers were found in the quality of execution of pre-development activities" [3]. Two factors were identified to play a major role in product success: the quality of executing the pre-development activities, and a well defined product and project prior to the development phase [4]. Another study identified the front end as an important contributing factor to large numbers of really new products introduced each year [5].

Most of the empirical studies of the fuzzy front end are focused on direct contributions of the fuzzy front end to project success. However, the literature indicates that activities during product development are interrelated and besides a direct effect they might have an indirect effect on project outcome as well [see, e.g., 6, 7, 8, 9]. In addition, the contingency approach stresses the influence of contextual factors on the product development process and project outcome. Depending on the situation, different factors become more or less important [see, e.g., 10, 11, 12]. The aim of this paper is to describe front end activities in practice and to find hints for direct and indirect effects of the fuzzy front end on project outcome and contextual factors influencing the fuzzy front end.

The framework and methodology of our exploratory study and a description of the sample are presented in the next section. The third section shortly summarizes our findings about the latter phases of new product development as a basis of a detailed discussion of the fuzzy front in section four. Finally, this paper highlights managerial implications and gives suggestions for future research.

THE STUDY

Study design

Figure 1 shows the framework of the exploratory study. Front end activities include idea generation, idea assessment, the reduction of market and technological uncertainty, and project planning. Cooper, too, divides the fuzzy front end into four phases from idea generation, initial screening, and preliminary evaluation to concept evaluation and stresses the importance of both market-related and technical activities [13]. Khurana and Rosenthal define the front end "to include product strategy formulation and communication, opportunity identification and assessment, idea generation, product definition, project planning, and executive reviews" [14]. In contrast to them, we focus on project-related activities and exclude strategic aspects from our study. In our point of view, during the product development process information is gathered to reduce uncertainty, whereby uncertainty is defined as the difference between the amount of information required to perform a particular task, and the amount of information already possessed by the organization [15]. We assume, that the more uncertainty about the market and technology is reduced during the front end, the lower deviations from front end specifications during the following project execution phase and the higher the product development success. This uncertainty reduction point of view is shared by several authors [e.g., 16, 17, 18].

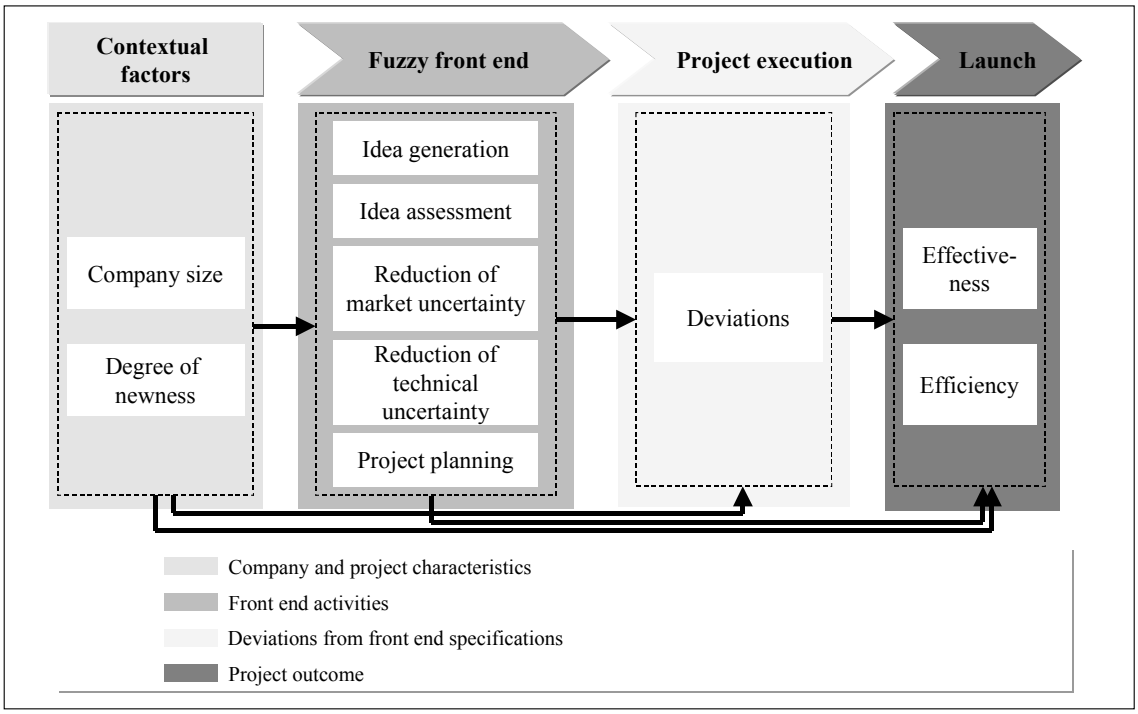

Figure 1: Framework of the study

Factors describing a situation which might have an impact on the new product development process are manifold. We focus on companies in similar industrial sectors and a certain region in Germany and therefore assume regional or sector-related contextual factors to be constant to reduce the complexity of the study.

In our study, we consider the size of a company and the degree of newness of the new product to a company as critical contextual factors. The importance of the degree of newness has been highlighted by numerous studies [e.g., 8, 9, 10, 11, 12, 16, 19].

Methodology

A total of 102 mechanical and electrical engineering companies located in Hamburg (Germany) were identified in the Hoppenstedt database [20] and contacted by telephone. Seven mechanical engineering companies and seven electrical engineering companies agreed to participate in our study. In-depth interviews were conducted with managers responsible for the development of new products during 2001. The majority of the interviewees were directors of the Research and Development department (R&D) or general managers. In three companies, both, the R&D director and Marketing director were interviewed. The interviewees were first asked to describe the development process and outcome of the last product launched (last incident method) with the focus on front end activities. The second part of the interview was based on a standardized questionnaire. The majority of the items were measured on a 7-point scale. This two-stage approach was supposed to facilitate the comparability of the different interviews and in parallel ensure that all aspects considered important by the interviewees were covered by the standardized questions. In the analysis, answers were merged into two to three categories to enhance the clearness of our results.

Sample

Size of the companies

Figure 2 and 3 show the number of employees and the annual sales of the companies in 2000.

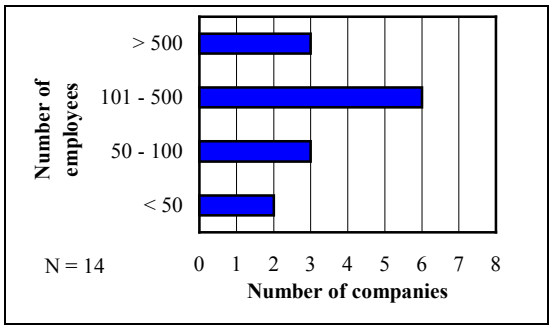

Figure 2: Number of employees

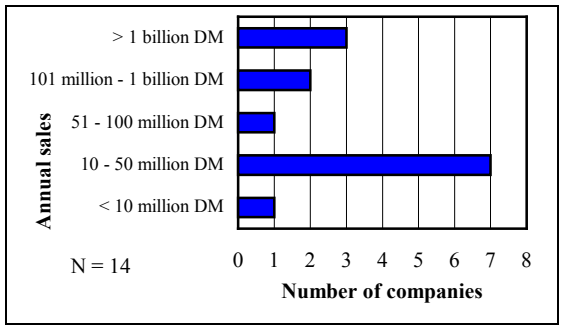

Figure 3: Annual sales

The sample contains three large enterprises with 11000, 200000, and 420000 employees and annual sales above one billion DM. However, the majority of the sample consists of small and medium-sized enterprises (SMEs) with 25 to 360 employees and annual sales from 4 to 150 million DM.

Scope of the projects

The average development time for the new products was 20 month with average personnel expenses of three man-years. In thirteen of the fourteen companies, the development costs were determined by personnel costs and ranged from 40000 DM to 4,5 million DM with an average of 950000 DM. Four projects exceeded one million DM.

Degree of newness of the projects

The interviewees classified the newness of their product concepts (see figure 4) and assessed the overall degree of newness of the product concept to their company (see figure 5).

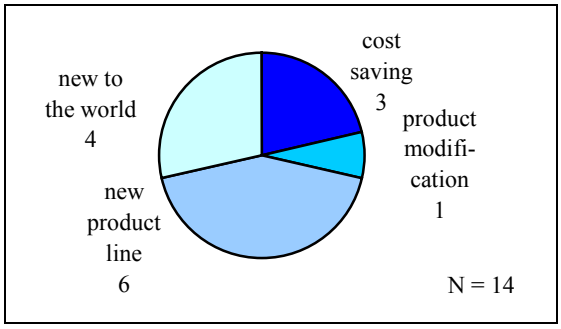

Figure 4: Classification of the concept

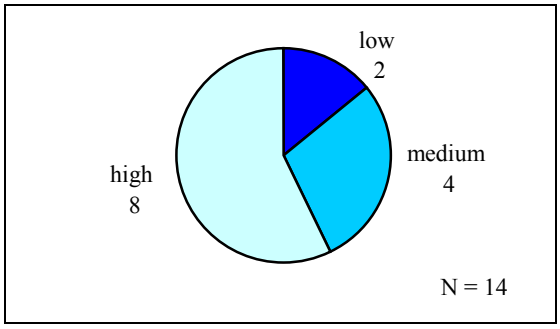

Figure 5: Degree of newness

The overall subjective assessment of the degree of newness to the company does not correspond to the rather objective classification in categories. Whilst, as expected, two of the three cost savings were rated as low, one was even rated as high. The four product concepts rated as medium were new product lines. There seems to be a tendency to overestimate the degree of newness in an overall assessment. This was confirmed by a large-scale study [19]. Therefore, we additionally collected data on single aspects of the degree of newness. The interviewees were asked to what extent new skills had to be developed that were not yet available in the respective company (see figure 6).

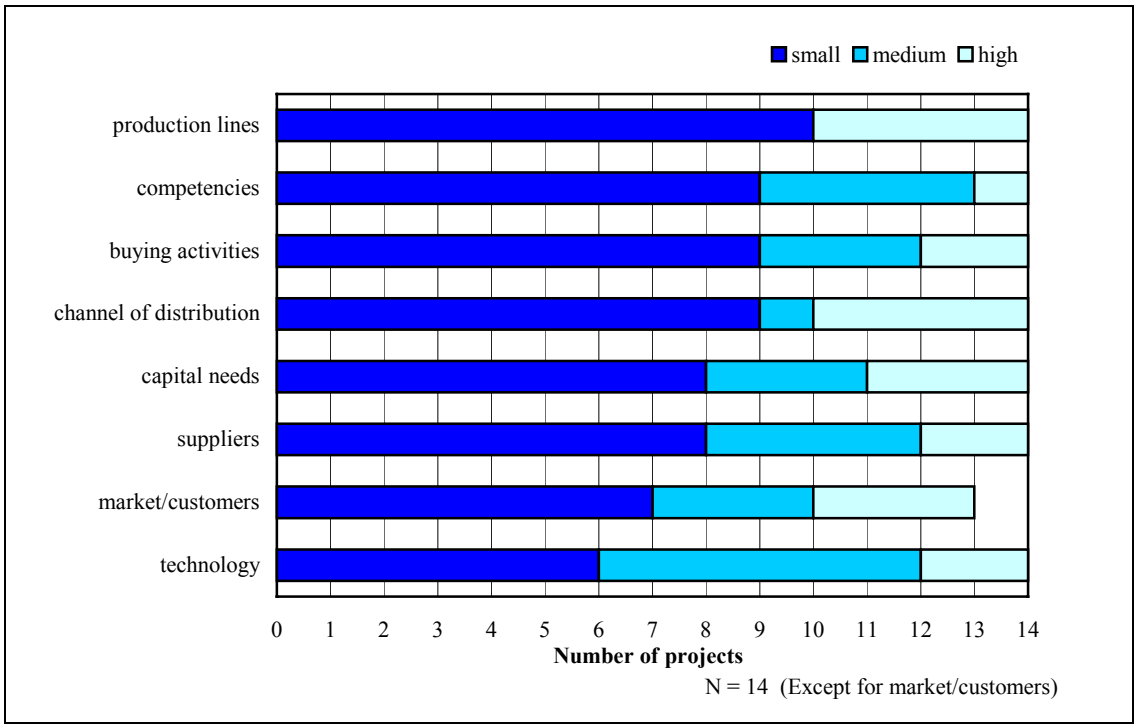

Figure 6: Single aspects of the degree of newness

The newness of the technology to the company is the only aspect which is medium or high for more than half of the companies (eight companies). The other aspects were rated as medium or high by five to six of the companies, except for the need for new production lines, which was high in four companies. The other eight product concepts could be realized with existing production lines. In general, SMEs possess less

resources than large companies. This is among other things reflected by the factor capital needs which particularly in SMEs exceeded formerly unknown levels.

In comparison to the overall assessment of the degree of newness to the company, the average of the single aspects of the degree of newness is low for eight and medium for six of the fourteen companies. As already mentioned above, the measurement of the degree of newness with a single item delivers higher values than a more objective classification or the assessment of several aspects [19]. Experience in innovation and attitudes towards innovation presumably influence the assessment. Companies or individuals which are seldom involved in the development of new products may regard small deviations from existing products or procedures as a high degree of newness to the company.

THE LATTER PHASES OF THE PRODUCT DEVELOPMENT PROCESS

The proceeding section included a description of the contextual factors. This chapter shortly describes the latter phases of the development process to complete the foundation of an in-depth analysis of the fuzzy front end in the next section. More precisely, this section treats deviation from front end specifications during project execution and the outcome of projects.

Deviations from front end specifications during project execution

Several studies show that well-defined deliverables and procedures during the fuzzy front end reduce deviations from this specifications during project execution and therefore foster project success [e.g., 1, 21, 22]. Figure 7 shows deviations from front end specifications during the fourteen projects of our study.

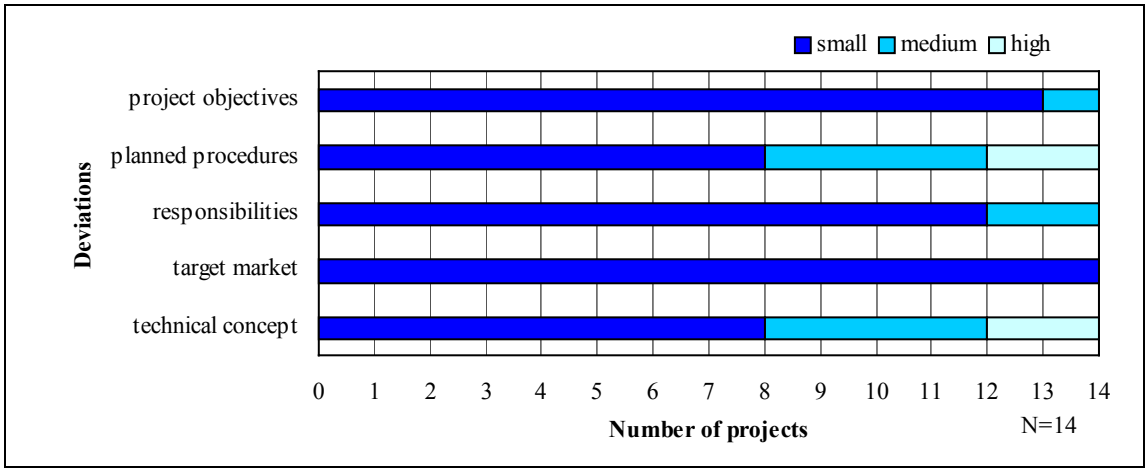

Figure 7: Deviations from front end specifications

Target market and project objectives were steady throughout almost all of the new product development processes . During two projects, responsibilities of team members were changed slightly. Substantial modifications are limited to the technical area, where the technical concept and/or procedures agreed during the fuzzy front end were changed during the execution of eight of the fourteen projects. Therefore, the analysis of the fuzzy front end in the following section focuses on technical deviations.

Success on the project level

Efficiency

The interviewees were asked, to what extent they agreed to statements concerning the compliance with time, financial, and personnel resources planned during the fuzzy front end (see figure 8).

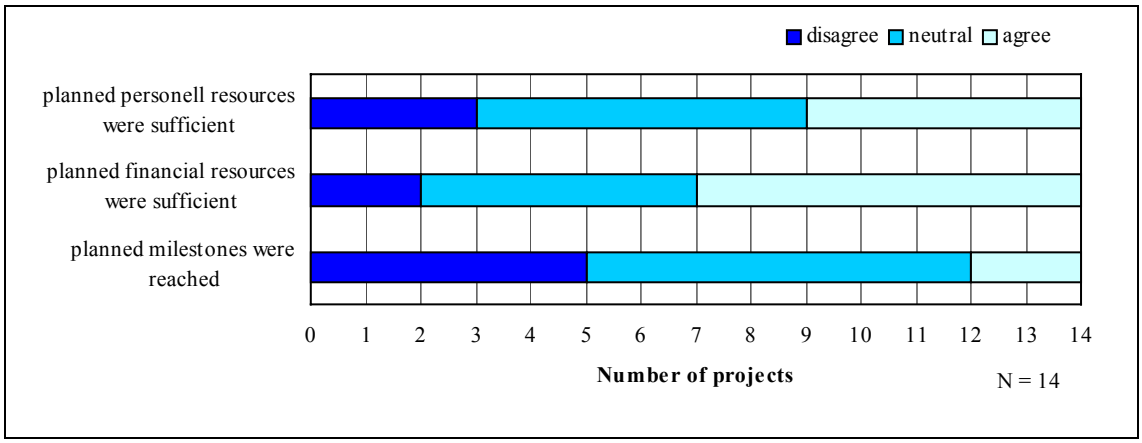

Figure 8: Compliance with planned resources

Milestones were reached in only two projects. Planned financial resources were sufficient in seven and planned personnel resources in five of fourteen projects. This means that several of the projects did not achieve efficiency targets.

Effectiveness

To assess the effectiveness of the projects, the interviewees were asked, if objectives existed and if yes, were achieved (see figure 9).

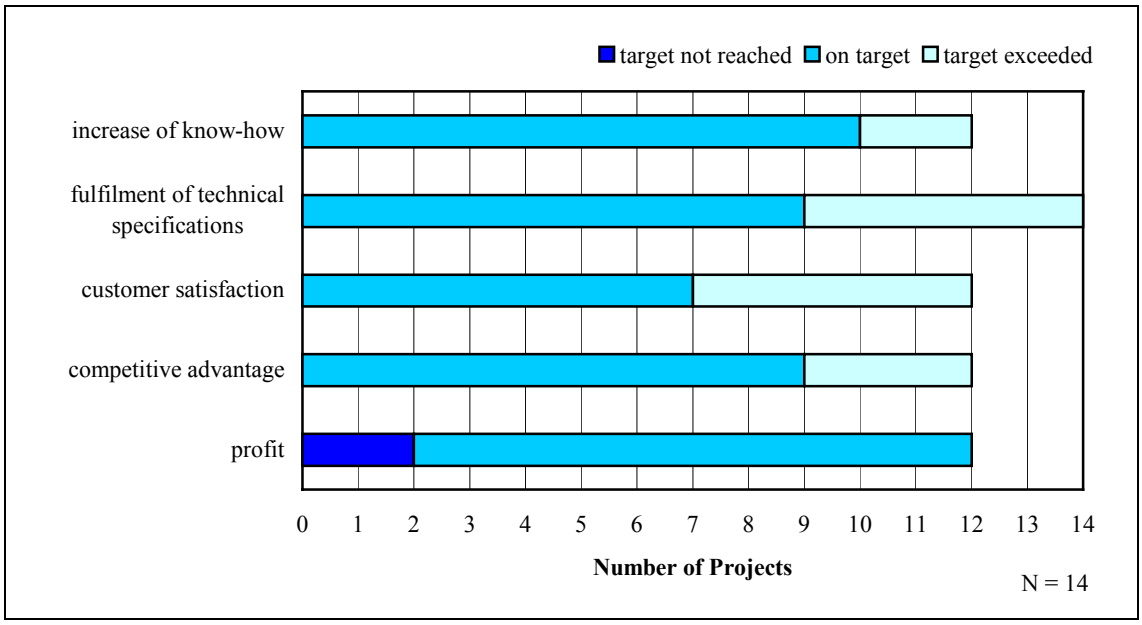

Figure 9: Achievement of objectives

All projects had objectives regarding the fulfilment of technical specifications. Other objectives like the competitive advantage and increase of know-how were important

for twelve to thirteen of the fourteen projects. One company was not yet able to assess profits and another to assess customer satisfaction.

Overall, the effectiveness of the projects was high. Projects were on target or even better with regard to the different objectives, except for two projects which did not attain their target profits. Therefore, it is not possible to analyse effects of the product development process on project effectiveness. An alternative would have been to ask every company to describe a successful project and a failure. This strategy was not chosen due to the fact that the interview length was too restricted to examine two product development processes in detail.

Overall assessment

Most objectives were reached, no interviewee was altogether dissatisfied (see figure 10).

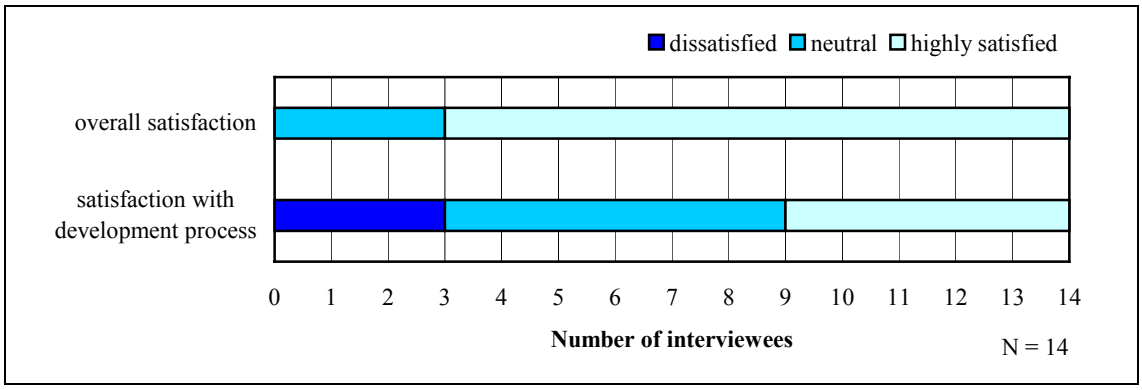

Figure 10: Overall assessment of project success

In contrast, corresponding to deficiencies with regard efficiency, three interviewees were dissatisfied with the development process and only five were highly satisfied (see table 1). Cross table 1 and 2 indicate that the satisfaction with the development process enhances with increasing compliance with financial and personnel resources.

		Satisfaction with development process			
		dissatis-fied	neutral	highly satisfied	sum
Planned financial resources were sufficient	disagree	1	1	-	**2**
	neutral	1	4	-	**5**
	agree	1	1	5	**7**
	sum	**3**	**6**	**5**	**14**

Table 1: Cross table 1

		Satisfaction with development process			
		dissatis-fied	neutral	highly satisfied	sum
Planned personnel resources were sufficient	disagree	2	-	1	**3**
	neutral	1	4	1	**6**
	agree	-	2	3	**5**
	sum	**3**	**6**	**5**	**14**

Table 2: Cross table 2

THE FUZZY FRONT END OF THE PRODUCT DEVELOPMENT PROCESS

The previous sections focused on contextual factors, project execution, and project outcome. This section summarizes our key findings about the fuzzy front end, the influence of contextual factors on the fuzzy front end, and the influence of the fuzzy front end on project execution and project success. As already outlined in the previous section, we focus on deviations in the technical area during project execution. With regard to project success, we have to focus on efficiency as the projects of our sample do not differ from effectiveness.

Firstly, we examine if the idea was initiated by the market and/or the technical area. Secondly, we describe how the idea was generated, assessed, and selected. Thirdly, we summarize to what extent market and technological uncertainty were reduced before project execution started. Finally, we describe the intensity of project planning activities as a basis of controlling during the following product development process steps.

Initiation

In the past, it was differentiated between products that were consumer or market driven ("market pull"), or enabled by technology development ("technology push"). The recent literature emphasizes the need for market and technical strength, i.e., "dual-driven" product development [e.g., 23, 24, 25]. In our study, five projects were solely market-driven and one project was technology-driven. The other eight projects were "dual-driven" (see table 3). Market seems to slightly outrank technology as a source of new product ideas: while eight projects were not at all driven by technology, only three projects were not market-driven. The technology-push project was a new-to-the-world-product with a high degree of newness to the company. Eight of the fourteen projects were originated by direct contact to customers, among them four of the five market-pull projects.

		Technology push			
		no	neutral	yes	sum
Market pull	no	1	1	1	**3**
	neutral	2	1	-	**3**
	yes	5	1	2	**8**
	sum	**8**	**3**	**3**	**14**

Table 3: Cross table 3

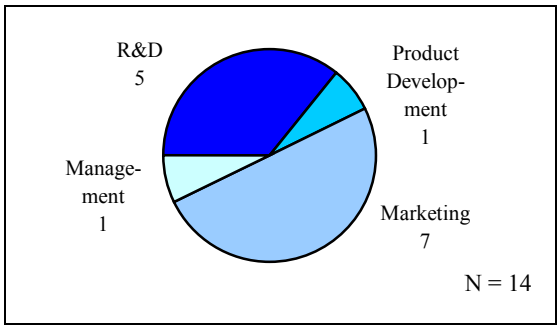

Figure 11: Initiating department

Figure 11 shows, which department of the company initiated the project. Marketing initiated seven and R&D five projects. As expected, the origin of the technology-push project was R&D, whereas the origin of three of the five market-pull projects was Marketing. The other two market-pull projects were initiated by a Product Development Department and, in a small company, by the General Manager himself.

Idea generation

Some authors suggests that individual idea generation produces more creative solutions than groups [see 26]. However, most authors favour an interdisciplinary group for idea generation [25, 26]. R&D and Marketing should cooperate to ensure

that customer needs and technology means can be combined to satisfy those needs [25]. There is also a widely held view that companies should set time aside for idea generation [see 26].

Figure 12 shows the results of our study: Only three ideas were not generated by an interdisciplinary team. Five interviewees stated that there was no scope for idea generation. This was the case for SMEs, where the personnel and financial resources are limited. Firstly, there are often not many individuals that could generate ideas or even form an interdisciplinary team. Secondly, employees are mostly involved in current business and have no time to develop new product ideas. This finding is reinforced by the fact that the scope for idea generation was assessed for ideas that despite lack of time were realized.

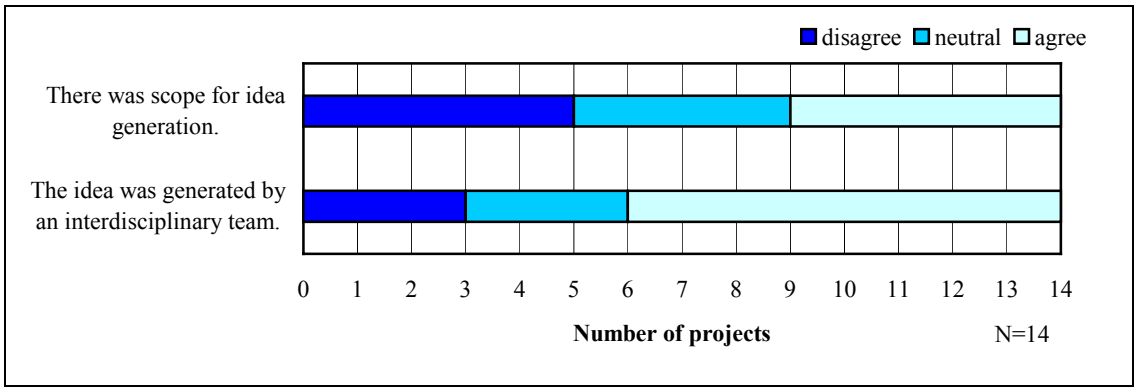

Figure 12: Idea generation

The present study confirms former findings about the rare use of tools and methods to support the generation of new ideas [27, 28]. Eleven of the fourteen companies did not use well-known and easy to use creativity techniques like brainstorming.

Overall, SMEs seem to lack resources to continually search for new product ideas. A systematic generation and compilation of ideas supported by methods and tools was observed in only one of the fourteen projects. The respective company uses a self-made innovation handbook.

Idea assessment

The purpose of idea assessment is to decide on the execution of an idea or to select the most promising idea from alternatives. The importance of this step of the product development process is highlighted by several authors [e.g., 3, 4, 24]. Criteria have to be developed to evaluate the ideas. These criteria are primarily technical or market-related. Studies identified a proficient financial analysis as a key success factor [29, 30]. Methods used for idea selection can be categorized as ranking, economic decision theory, portfolio optimization, cognitive modeling, and ad hoc decision methods [31]. Some authors suggest an interdisciplinary idea assessment to ensure that all facts and points of vies are taken into consideration [32, 33].

Six of the fourteen companies of our study had to realize the idea anyway for various reasons. One of the companies, e.g., had to adopt to a technical change in the target market. These six companies assessed the idea but did not have to select between alternatives. Therefore, in the following analysis, only the remaining eight companies which had a project selection step in their product development process are considered.

Figure 13 shows that three of the eight projects were not selected by an interdisciplinary team. In general, interdisciplinary idea selection took part in meetings. One company held a meeting with participants from one department only. All the ideas that were selected by an interdisciplinary team were already generated by multiple functions. As already outlined in the previous paragraph about idea generation, the idea selection step was dominated by one function in SMEs, in some cases by the general manager himself.

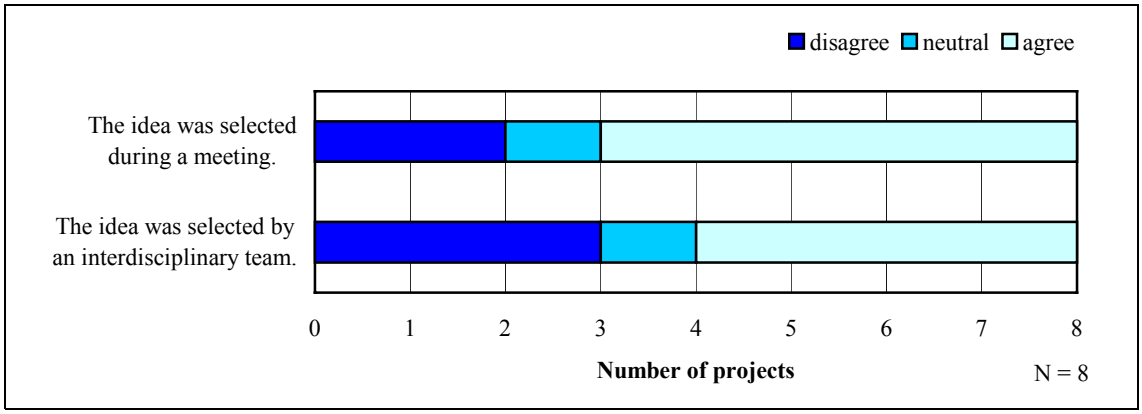

Figure 13: Idea selection

Table 4 shows the importance of technical and market-related criteria for the selection of an idea. None of the eight companies focused on technical or market-related criteria only for the selection of the respective idea. Three considered both as very important, two (three) considered market-related (technical) criteria as more important.

		Technical criteria			
		not important	neutral	very important	sum
Market-related criteria	not important	-	-	-	**-**
	neutral	-	-	3	**3**
	very important	-	2	3	**5**
	sum	**-**	**2**	**6**	**8**

Table 4: Importance of technical and market-related selection criteria

Concerning selection methods, for five of the eight projects a cost effective analysis was done. Two of the three large enterprises did a cost effective analysis. The selection criteria were weighted in four projects, i.e. a kind of scoring model was applied.

To summarize, if the idea was generated by an interdisciplinary team, it was also selected by several functions. None of the projects studied solely relied on technical or market-related criteria. Only half of the selection steps were supported by a cost effective analysis or a scoring model. Consistent with former studies [34, 35], it seems to be more likely for large enterprises to use these methods.

Reduction of market uncertainty prior to development

In this paper, we take an uncertainty reduction view to the new product development process. Numerous studies highlight the importance of the reduction of market uncertainty/the proficiency of marketing activities during the fuzzy front end [e.g., 3, 6, 8, 16, 30, 36, 37, 38]. Customer requirements should be integrated into the product concept [3, 4, 36], the target market defined, and consumer needs understood prior to development execution [3, 36, 37]. In new or rapidly changing markets, the customers are not able to articulate their needs which makes the reduction of market uncertainty more difficult [18].

Figure 14 shows the results of our study: three product definitions did not integrate customer requirements at all. Among eight projects that were originated by direct contact to customers, six integrated customer requirements into the product definition.

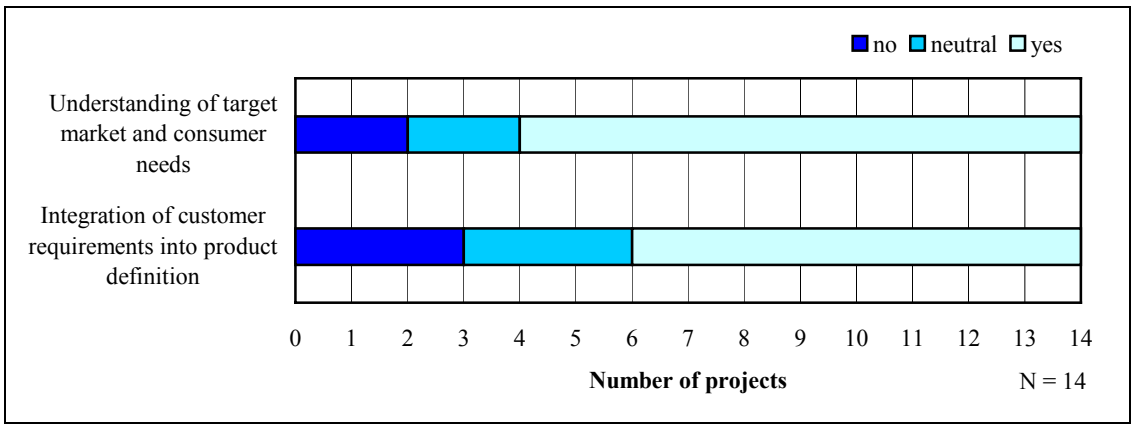

Figure 14: Reduction of market uncertainty prior to development

Target market and consumer needs were not known prior to the execution of the respective project by two companies. There seems to be a correlation between the two ways described to reduce market uncertainty: The more customer requirements are integrated into the product definition, the better the target market is defined and consumer needs understood prior to development. Although a direct impact of the reduction of market uncertainty on project outcome could not be observed in our study, an indirect impact was found: Procedures agreed during the fuzzy front end were not changed during project execution, if the target market and consumer needs were well understood prior to the development phase.

To summarize, this study slightly supports the relevance of the reduction of market uncertainty during the fuzzy front, which was achieved for the majority of the projects.

Reduction of technical uncertainty prior to development

According to Moenaert, successful and unsuccessful projects differ by a wider gap on the information acquired on the technology [16]. Cooper and Kleinschmidt, too, highlight the strong relation of preliminary technical assessment to project outcomes [39]. Preliminary technical assessment, according to them, includes among other things feasibility analysis and definition of product specifications. In their study, preliminary technical assessment was undertaken in 85 % of projects and rated as proficiently undertaken.

Our results are similar: Technical requirements were not defined in two, and technical feasibility not verified in one of fourteen projects (see figure 15).

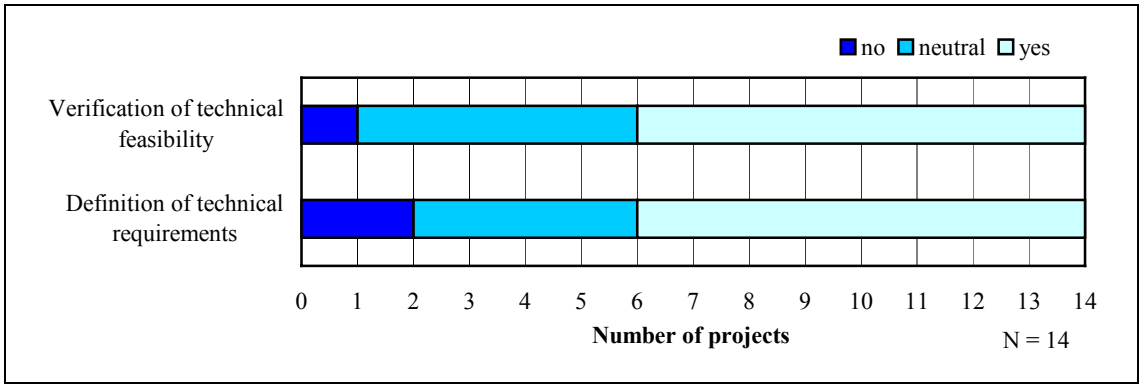

Figure 15: Reduction of technical uncertainty prior to development

In addition, technical feasibility analysis seems to be of particular importance for products which have to be produced on new production lines. For all of the projects where this was the case (five of fourteen), a detailed technical feasibility analysis was done. Similar to our results concerning market uncertainty, a direct impact of the reduction of technical uncertainty on project outcome could not be observed in our study. Nevertheless, again, an indirect impact was found: Procedures agreed during the fuzzy front end were not changed during project execution if technical feasibility was checked prior to the development phase.

Overall, data seems to suggest that, within the present sample, the reduction of market as well as technical uncertainty has a positive impact on project execution and therefore indirectly on project success. In the majority of projects, both kinds of uncertainty were reduced prior to development.

Project planning

The first step of front-end project planning is to break the product development project down into work packages. In a second step, timings and resources are allocated to the work packages. In addition, costs projections should be made and responsibilities assigned. Project planning can be supported by several tools and methods, e.g,. bar charts, network plans, or project management software [22]. Several studies suggest a positive impact of a thorough planning on project outcomes [1, 10, 22, 35, 37].

In the present study, most of the projects were broken down into work packages, resources were allocated, costs projections made, and responsibilities assigned (see figure 16). Except for two projects, a front-end planning was done with deficiencies in no more than two of these activities. Two projects did not have a front-end planning at all. As expected, this was the case for product development projects in small firms (25/140 employees) and resulted in a low efficiency. The three large enterprises of our sample carried out a detailed planning in every aspect. Whilst eleven companies made flow charts (e.g., bar charts, network plans), only four companies used a project management software. This supports former findings that project management software is not widely-used [see 35].

The interviewees were asked to assess the thoroughness of their front-end planning. Two of the interviewees were not able to give an overall assessment, however, they gave a high rating in all of the planning activities. Surprisingly, although the remaining twelve projects had deficiencies in their front-end planning or did not even plan at all, for half of them the thoroughness of planning was considered medium and

for the other half high. Overall, the interviewees did not seem to attach importance to front-end planning and consequently assessed their planning activities as sufficient.

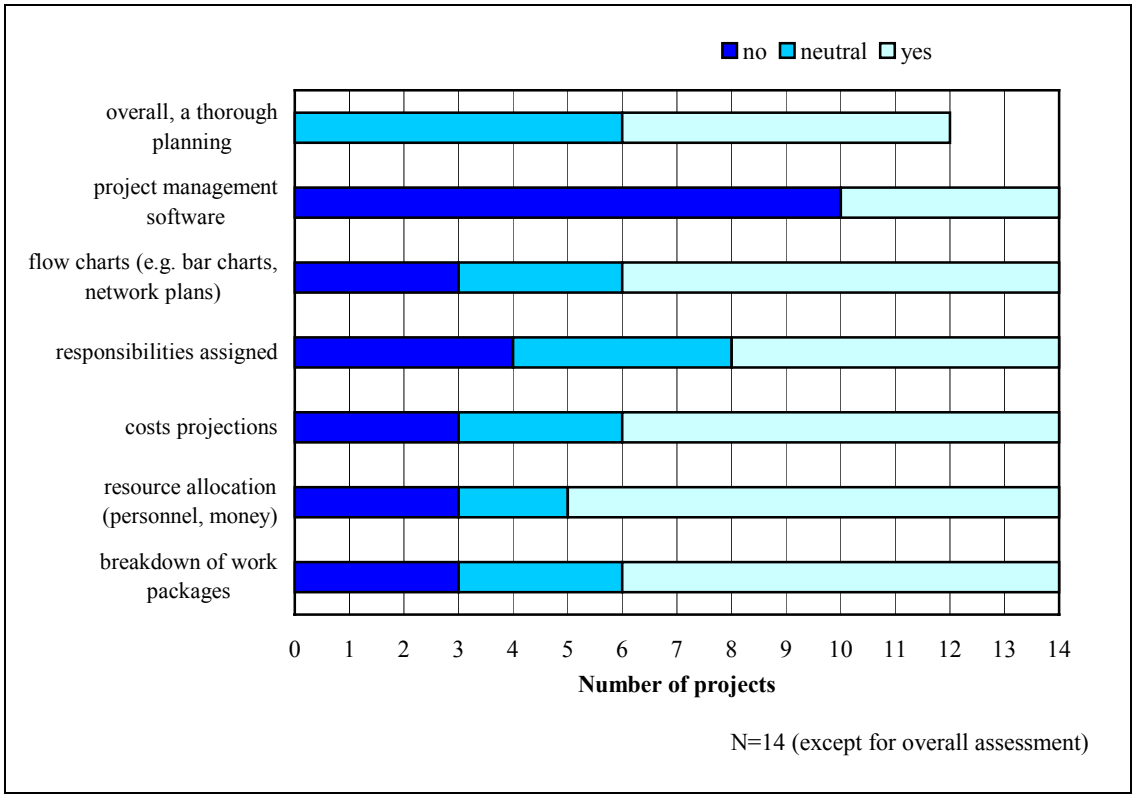

Figure 16: Front-end project planning

As already mentioned above, deficiencies in front-end planning directly reduced projects efficiency. In addition, there are hints for indirect effects. The allocation of resources, costs projections, and clear responsibilities reduced deviations from the technical concept defined prior to the start of the project during project execution. If a time schedule was made and resources were allocated (eleven projects), deviations were small (seven/eight projects) or medium (four/three projects). The same is true for costs projections and in particular for clear responsibilities which seem to be a powerful way to reduce deviations during project execution (see table 5).

		Deviations from technical concept			
		small	medium	high	sum
Respon-sibilities assigned	no	-	1	2	**3**
	neutral	2	1	-	**3**
	yes	6	2	-	**8**
	sum	**8**	**4**	**2**	**14**

Table 5: Definition of responsibilities and deviations during project execution

Overall, our study confirms that large enterprises carry out a detailed front-end planning. For SMEs, the intensity of planning ranges from not carried out at all to a detailed planning, and is therefore not reconfirmed as a general insufficiency of SMEs. A thorough front-end planning reduces deviations from front-end specifications during project execution and enhances the overall efficiency of projects.

CONCLUSIONS

The results of our study are contrary to the wide-spread opinion of a low quality of front-end activities in practice. For the majority of the fourteen projects we described, ideas were assessed and carefully selected and market und technical uncertainty reduced prior to development. Only regarding front-end planning, some projects suffered from a low quality of execution. Consequently, effectiveness of the projects was high and efficiency varied.

Despite the small sample size, some hints were found for direct and indirect impacts of pre-development activities on project outcome. Besides directly enhancing project effectiveness and efficiency, an emphasis on the fuzzy front end seems to reduce deviations in the latter development phase.

Furthermore, company size and degree of newness of a project to a firm were found to impact on the fuzzy front end. Large enterprises seem to have a more systematic front-end process and rather use methods and tools (e.g., selection methods or planning tools) than SMEs. In addition, due to limited resources, SMEs often do not continually search for new product ideas. Nevertheless, the quality of execution of pre-development activities varied for the SMEs of our sample, a general deficiency with regard to the fuzzy front end could not be found.

Managerial implications

In general, SMEs could profit from a systematic approach, methods, and tools used in larger enterprises. In addition, they should place emphasis on the generation of new ideas and not solely rely on current business and input from current customers.

Well-defined front-end specifications can help to reduce deviations during project execution. If possible, target markets and consumer needs should be understood and the product defined prior to development. With regard to technology, technical feasibility should be verified and technical requirements defined prior to development. Regarding front-end planning, in particular clear responsibilities reduce deviations.

Suggestions for future research

Due to the small sample size of our study, the findings are limited and cannot be generalized. Nevertheless, first hints for direct and indirect effects of the fuzzy front end on project outcome were found. In addition, company size and the degree of newness of a project to a firm were identified as important contextual factors. These findings suggest a contingency approach. The framework of our study could be used to draft hypothesis and test them in a large-scale study. Interrelationships, direct and indirect effects could be evaluated with structural equation models. In addition, the influence of further contextual factors on the fuzzy front end should be considered. In our study, we focused on two similar branches in one country which reduced the amount of possible contextual factors.

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