INTERNATIONAL CONFERENCE ON ENGINEERING DESIGN, ICED'09
24 - 27 AUGUST 2009, STANFORD UNIVERSITY, STANFORD, CA, USA

MANAGING EARLY PHASES OF INNOVATION PROCESSES AND THE USE OF METHODS WITHIN – EMPIRICAL RESULTS FROM AN INDUSTRY SURVEY

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ABSTRACT
Innovation processes demand for a powerful and far sighted management. A key to manage innovation are measures, which need to comprise potential success factors in order to impact on validity. Companies have to prioritize their challenges within the topic of innovation and technology management. The paper introduces to measuring innovation success and proposes a combined index value. A survey focused on innovation processes and method application within 87 companies identifies potential success factors for new product development (NPD). The survey enlightens the intensity of method application within the development process. Results are related to successful and less successful companies and highlight the importance of systematic method application in NPD processes. The authors conclude that more efforts to explicitly define processes have to be done by the management. Furthermore the study indicates that the application of particular methods during the whole process leads to a higher innovation success.

Keywords: Survey, innovation process, new product development, methods, success factors, product innovation, empirical study, early phases, front-end of innovation

1 INTRODUCTION
Innovation is still a major topic for top management within the industry [1] [2]. Why is this? For the companies globalization is accompanied not only with advantages like new markets, global sourcing, using cost advantages, etc. but also with a global competition [3]. Beside globalization the time of technology development cycles decreases [4]. Innovation is an important strategy for gaining and sustaining a competitive capability [5] and creating not only short-term financial benefits through quasi-monopoly product advantages [6] but for sustainable success [7]. These are only a few arguments, why companies have to think about the management of technology and innovation.
Many examples in literature show that enterprises who are lacking the ability to adapt quickly to technological progresses and changes fail in the long term. [8-11]
But on the other hand - on a resource-based view - R&D and especially new product development (NPD) can be very expensive. For example the 1000 companies who reported the highest spending on R&D in 2004 invested more than 407 billion dollar on this topic. And there is evidence that above-average expenditures on R&D are no guarantee for more success [12].
For the top management and especially chief technology officers (CTO) the questions arise which strategies are the best for a lean and effective management of technology and innovation and which levers should be focused on when optimizing the innovation process of their company. Hereby the CTOs predominantly have to deal with special types of innovation (see figure 1).

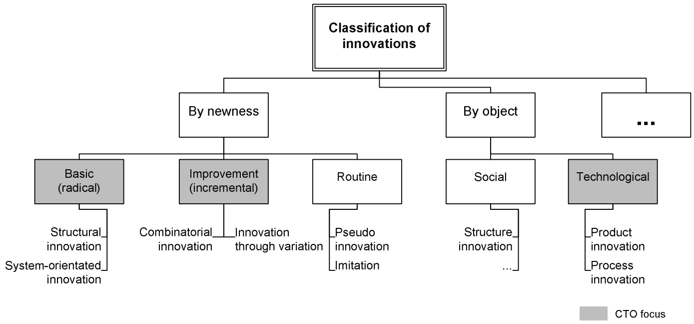


Figure 1: types of innovation (on the basis of [13])

2 BACKGROUND

In this chapter basic workings of other authors will be presented. Different possibilities and approaches how to measure the innovation success will be introduced. As an important topic in this chapter, the problems of measuring innovation success will be outlined, especially considering the design of surveys and the selection of metrics to measure success. Following the authors of this paper will explain the focus of their study and the set of metrics they used to measure success.

2.1 State of the Art and problems measuring innovation success

A lot of research in the area of innovation success and influencing factors of innovation and NPD success has been done in the last decades. Well-known examples are the SAPPHO studies [14], where successful and unsuccessful projects were compared and the NewProd studies from Robert G. Cooper et al. where up to 203 new products from 135 companies were analyzed [15]. But besides these well-known studies a lot more studies have been accomplished during the last years. Because of the huge number of published studies in this field even some meta-analyses have been developed. Montoya-Weiss and Calantone for example analyzed 47 studies [16]. And in his PhD thesis Papies analyzed even 72 studies [17]. The meta-analyses showed that the studies can hardly be compared because there are quite a few aspects which differ from study to study. Some studies like SAPPHO concentrate on several projects while others focus on R&D-programs or even whole companies. Figure 2 shows some of the study characteristics which make comparison difficult:

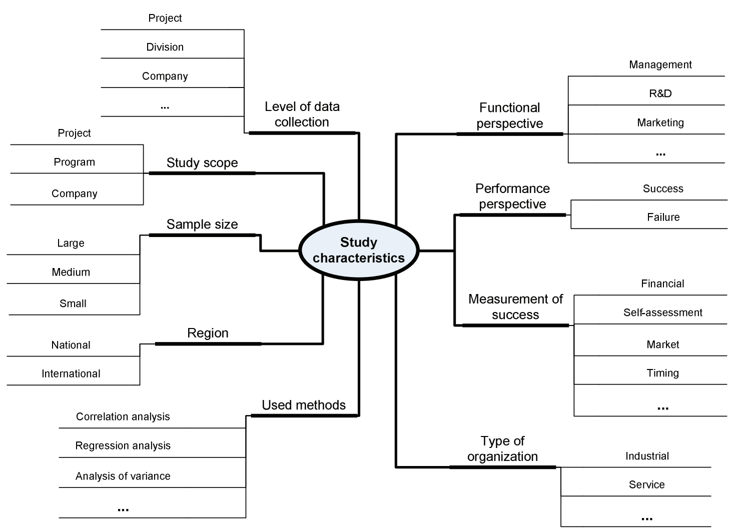


Figure 2: Possible characteristics of studies of innovation success (on the basis of [16], [17])

Hauschildt shows that the different characteristics in combination with other factors like information bias, deficits regarding content and methodology, equal treatment of incremental and radical innovations and information bias can lead to different results [19]. He also pointed out that the impact of the factor on success could change in the course of time. Furthermore Calantone et al. criticize an imprecise discrimination in terms like product advantage, product innovativeness and customer familiarity [18]. Beside the diverse characteristics of studies there are even more general problems to measure innovation success.

In literature there is no enduring and consistent definition of term 'innovation' itself. Hauschildt addresses this problem in his definitive book with the first 31 pages where he describes the different dimensions of innovations [19]. And even several dimensions like 'newness' again can be defined through multiple factors [20] [21]. Because of observed misunderstandings innovation also often is described besides the mentioned perspectives and the perspectives illustrated in figure 1 in discrimination to invention (e.g. [5], [22], [23]). Therefore it is hard for people in the industry to respond to such topics with a common understanding.

These difficulties imply that no general recommendations for specific companies should be made without a profound look at the data of the survey.

Despite these problems of measurement some promising factors or clusters of factors with effects on success were found in most of the studies (on basis of [19]):

- Technological factors (technical feasibility, technological potential, etc.)
- Strategic factors (fit between technological strategy and companies' strategy, etc.)
- Market- and customer-oriented factors (marketing synergy, market orientation, etc.)
- Organizational factors (support of top management, internal/external relations, etc.)
- Product-orientated factors (newness, product advantage, etc.)

In addition to the results of the studies, there are different approaches how success itself is defined and measured. Regarding to the meta-analysis of Papies between 1 and 11 metrics of measurement were used in his examined studies. A lot of the studies used 'hard' metrics like financial ratios (ROI, profitability, EBIT, growth in sales, etc.) or market share. Other studies focused on 'soft' metrics like image, success of new products relative to competitors, self-assessments of success, know-how gains and more. But most studies used a set of different metrics [17]. To get benefits from such studies, companies have to integrate data and insights into their own measurement system (see figure 3) as proposed by Kerssens-van Drongelen.

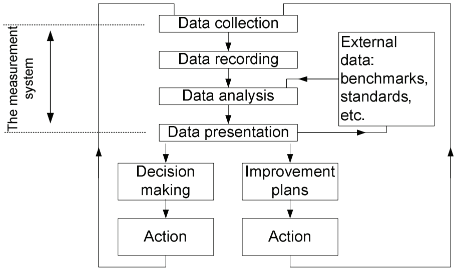


Figure 3: The measurement and control process [24]

For industrial relevance the chosen metrics have to fit to the purpose of the measurement and "must reflect the objectives for and responsibilities of the person(s) or activities that are being measured." [24]

2.2 Background of the study

Against this background, the Institute of Product Development of the Technische Universität München carried out a survey together with a consulting company to analyze possible influences and effects of methods on NPD success:

1. To question or verify the relevance of popular success factors for a specific sample of the industry;
2. To examine the criteria used for decision making in NPD method selection;

3. To give differentiated results depending on the different stages/phases of the innovation process.

The purpose of the planed analysis was to derive practical recommendations and strategies to improve company specific innovation systems. Of particular importance also was the timing when to apply which appropriate 'success factors'.

2.3 Metrics based approach to measure innovation success

According to the literature review a holistic approach seems most appropriate to measure the innovation success. Because of recent concerns that a short-term way of thinking can harm the long-term success [25] a mixture of short-term and long-term metrics is required. A set of six weighted metrics leads to one single index number. The composition of this index bases on literature review and various expert meetings, furthermore the consistence has to be validated in future research work. As a short-term financial metric the index includes 'operative return on sales' (EBIT/operative sales) and as long-term financial metric 'growth of operative EBIT within the last 5 years. Besides the financial perspective of success, the success rate of projects in the later stages in the development process (for details of the classification of the NPD-process see chapter 3) incorporates effective decision making in the early stages of the NPD process and efficient project management. 'Relative satisfaction of costumers' compared to the competitors provides an outside-in perspective regarding the standing and the image of the company. Finally a self-assessment of the innovativeness of the own company completes the set of metrics to cover an inside-out perspective. The index does not contain other metrics like 'number of patents' and 'R&D rate' following Gerpott's argumentation [26].

To increase the comparability of the results, the abovementioned metrics address the company or business unit level and not the level of individual employees.

Figure 4 illustrates the proposed metrics and their respective weights:

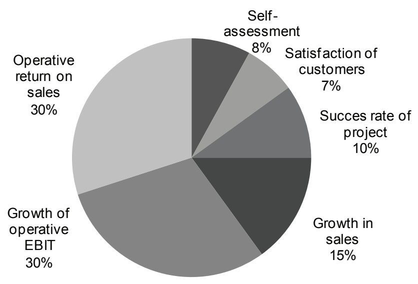


Figure 4: Metrics measuring the innovation success

An index is derived from the six metrics with the given weights. The range of the index is between 0 (no innovation success) and 100 (best innovation success). For the following analysis, a distinction is carried out between successful companies (index > 80) and underperforming companies (index < 60).

2.4 Common suggestions of strategic means to improve the innovation success

The engaged consulting company in the research project proposed a set of strategic means that typically are applied to improve the innovation success. This set of means on the one hand was derived from the experience of several consulting projects; on the other hand it is referred to by literature (e.g. [18]). The set of means is listed below:

1. **Integration of top management:** Time spent by high-level management is a very expensive factor. Thus, the question emerges if the direct participation in processes is profitable.
2. **Structured innovation process:** The question is whether a structured and standardized innovation process limits creativity and thus the innovation success.
3. **Method application:** The question is whether the application of methods correlates with the innovation success.
4. **Professional method training:** In order to increase the quality of applied methods, a professional training is a strategic means. The question is whether it correlates with the innovation success.

5. **Innovation Controlling:** The transparency of the innovation processes is increased by Innovation Controlling. The question is whether it correlates with the innovation success.
6. **Interface between innovation process (IP) and product development process (PDP):** The interface between the IP as described above and the classical PDP is also known as "Money Gate", as the development costs increase notably from this point. An important characterizing aspect of the design of this interface is the quantity and quality of conceptual information that is transferred. So the question is whether a complete handover of information at this point correlates with innovation success.
7. **Interdisciplinary teams:** The question is whether the results of interdisciplinary teams can increase the innovation success.
8. **Concurrent Engineering**: The same tasks are worked on by competing teams and the results are compared at a defined point. The best result is then the starting point for the next process phases. The question is, whether this means correlates with innovation success.
9. **Independent project time:** The policies of some innovative companies (e.g. 3M) allow their employees to work a defined share of their time to pursue independent projects. The question is whether this means correlates with innovation success.
10. **Portfolio Management:** The aim of Portfolio Management is a beneficial ratio of new and old products. Established products generate the financial resources for further actions, new products in the growing phase ensure future benefits. The question is, whether the application of a systematic Portfolio Management correlates with the innovation success.

For the corresponding correlation charts please refer to section 4.2.

3 METHOD

This chapter presents the design of the conducted study. The study aims to identify measures and methods and recommend courses of action that characterize successful innovation processes. First, a characterization of the sample's properties introduces the topic of the survey. The second part of this chapter describes the design of the questionnaire.

3.1 Properties of the sample

The study focuses on manufacturing industry for two reasons: On the one hand, the variation of applied measures and methods in this field is estimated larger than in other industry sectors such as mining etc., on the other hand the expertise of the authors in this field is profound and allows an intensive study and interpretation of the results. In detail, the study focuses on

- Machine and plant manufacture
- Electrical engineering
- Automotive engineering
- Consumer goods

Due to the complex topics of innovation management, only companies with a staff of at least 30 were considered. The assumption is that most companies of this size have development departments or at least persons responsible for managing innovation processes. As most companies in the manufacturing industry in the previously mentioned fields operate on international level, the survey was designed both in German and English language.

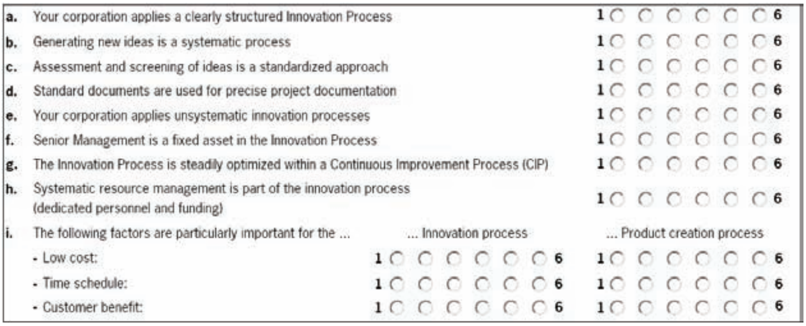
The later on specified sample bases on a selection of 2600 company contacts obtained with the assistance of the industrial partner and a commercial address database service. From this initial selection, 750 contacts qualified for the survey, as in their cases an appropriate department or personal contact was available. Thus, the items of this final population still represent a random sample. 12% of the 750 sent questionnaires were returned, i.e. the study bases upon 87 returns.

3.2 Questionnaire design

The questionnaire bases on a simplified model of an innovation process to prevent interpretation errors by the respondents. According to this model, the innovation process is considered the vanguard to the Product Materialization Process and consists of three steps:

1. Idea Generation (completing milestone: idea approved)
2. Concept Analysis (completing milestone: concept approved for validation)
3. Concept Validation (completing milestone: concept approved for further development)

The 4th step is the first process phase of the Product Materialization Process and will be denominated in the following analysis "Concept creation". Part of the questions was derived directly from the suggested means listed in chapter 2.4, whereas the collection of clustered supporting methods bases on a literature review (e.g. [19]). The sections of the questionnaire with relevance to the topics presented in this paper are depicted below for illustration purposes.



a.	Your corporation applies a clearly structured Innovation Process		1 ○ ○ ○ ○ ○ ○ 6
b.	Generating new ideas is a systematic process		1 ○ ○ ○ ○ ○ ○ 6
c.	Assessment and screening of ideas is a standardized approach		1 ○ ○ ○ ○ ○ ○ 6
d.	Standard documents are used for precise project documentation		1 ○ ○ ○ ○ ○ ○ 6
e.	Your corporation applies unsystematic innovation processes		1 ○ ○ ○ ○ ○ ○ 6
f.	Senior Management is a fixed asset in the Innovation Process		1 ○ ○ ○ ○ ○ ○ 6
g.	The Innovation Process is steadily optimized within a Continuous Improvement Process (CIP)		1 ○ ○ ○ ○ ○ ○ 6
h.	Systematic resource management is part of the innovation process (dedicated personnel and funding)		1 ○ ○ ○ ○ ○ ○ 6
i.	The following factors are particularly important for the ...	... Innovation process	... Product creation process
	- Low cost:	1 ○ ○ ○ ○ ○ ○ 6	1 ○ ○ ○ ○ ○ ○ 6
	- Time schedule:	1 ○ ○ ○ ○ ○ ○ 6	1 ○ ○ ○ ○ ○ ○ 6
	- Customer benefit:	1 ○ ○ ○ ○ ○ ○ 6	1 ○ ○ ○ ○ ○ ○ 6

Figure 5: Detail of questionnaire - Innovation process basic information

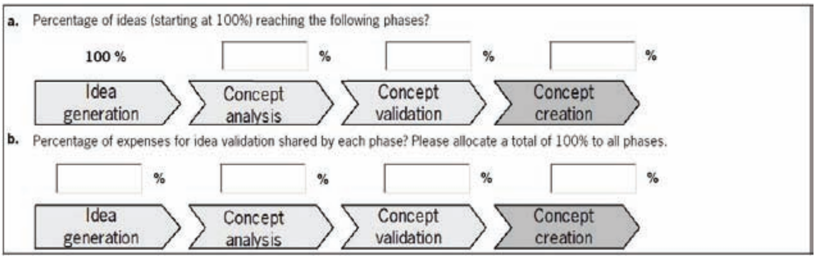
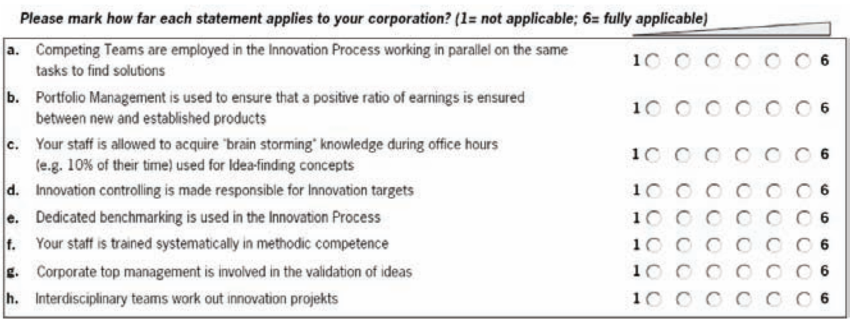


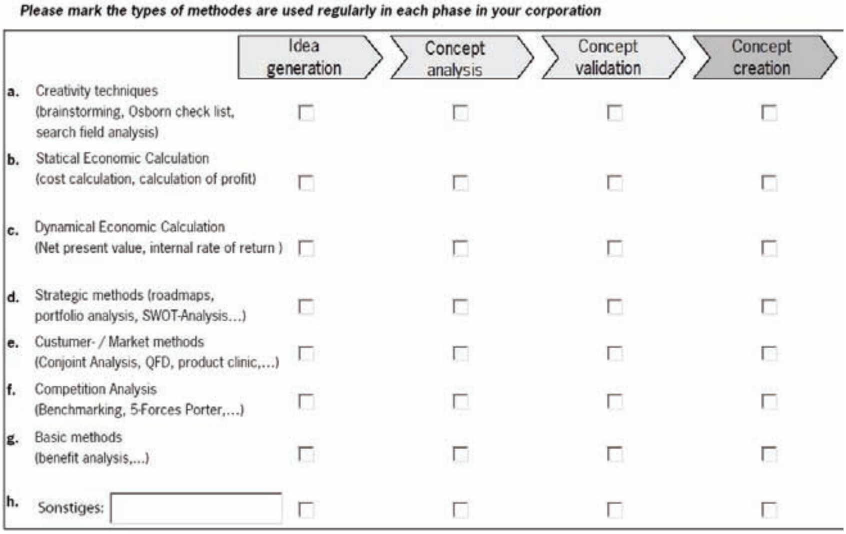
Figure 6: Detail of questionnaire - Innovation process over time



Please mark how far each statement applies to your corporation? (1= not applicable; 6= fully applicable)

a.	Competing Teams are employed in the Innovation Process working in parallel on the same tasks to find solutions	1 ○ ○ ○ ○ ○ ○ 6
b.	Portfolio Management is used to ensure that a positive ratio of earnings is ensured between new and established products	1 ○ ○ ○ ○ ○ ○ 6
c.	Your staff is allowed to acquire "brain storming" knowledge during office hours (e.g. 10% of their time) used for Idea-finding concepts	1 ○ ○ ○ ○ ○ ○ 6
d.	Innovation controlling is made responsible for Innovation targets	1 ○ ○ ○ ○ ○ ○ 6
e.	Dedicated benchmarking is used in the Innovation Process	1 ○ ○ ○ ○ ○ ○ 6
f.	Your staff is trained systematically in methodic competence	1 ○ ○ ○ ○ ○ ○ 6
g.	Corporate top management is involved in the validation of ideas	1 ○ ○ ○ ○ ○ ○ 6
h.	Interdisciplinary teams work out innovation projekts	1 ○ ○ ○ ○ ○ ○ 6

Figure 7: Detail of questionnaire – Strategic means



Please mark the types of methodes are used regularly in each phase in your corporation

	Idea generation	Concept analysis	Concept validation	Concept creation
a. Creativity techniques (brainstorming, Osborn check list, search field analysis)	☐	☐	☐	☐
b. Statical Economic Calculation (cost calculation, calculation of profit)	☐	☐	☐	☐
c. Dynamical Economic Calculation (Net present value, internal rate of return)	☐	☐	☐	☐
d. Strategic methods (roadmaps, portfolio analysis, SWOT-Analysis…)	☐	☐	☐	☐
e. Custumer- / Market methods (Conjoint Analysis, QFD, product clinic,…)	☐	☐	☐	☐
f. Competition Analysis (Benchmarking, 5-Forces Porter,…)	☐	☐	☐	☐
g. Basic methods (benefit analysis,…)	☐	☐	☐	☐
h. Sonstiges:	☐	☐	☐	☐

Figure 8: Detail of questionnaire - Applied methods

Additionally, the questionnaire included 14 questions to analyze the economic situation of the participating company. These answers finally led to the metric for the measuring of the innovation success.

4 RESULTS

In this chapter, the corresponding results of the survey will be presented. In a first Analysis of Variance (ANOVA), the response behavior of the four focused industries - machine and plant manufacture, electrical engineering, automotive engineering and consumer goods - was analyzed. The ANOVA proved that in most answers no significant differences between the industries could be identified. Certainly ANOVA's short-comings concerning complex analyses have been considered in separate analyses. On this basis, the next results will not differentiate between the industries, where possible.

4.1 Innovation success vs. use of methods in NPD

In order to quantify the intensity of the use of methods, an index was created by adding up the numbers of confirmed method applications (see Figure 8). The method groups were not weighted for this index number. Figure 9 depicts the correlation between this index and the innovation success.

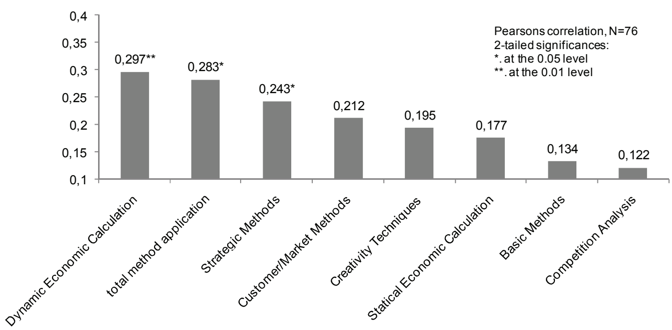


Figure 9: Correlation between Innovation Success and applied method groups

Only the application of Dynamic Economic Calculation methods has a highly significant and positive correlation with the innovation success. The overall numbers of applied methods and the group of Strategic Methods have a somewhat weaker positive correlation, but still with a significance below the .05. The other method groups have no correlation with a reasonable significance level.
The parallel analysis of method application in different innovation process phases by both successful and underperforming (referring the measurement index introduced in section 2.3) companies leads to the following results:

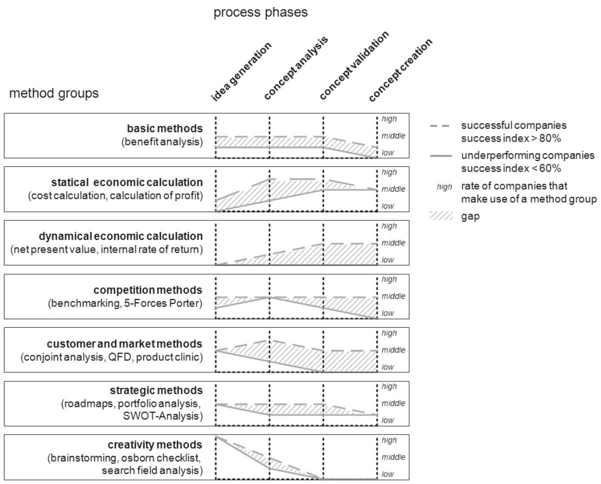


Figure 10: Application of method groups in different process phases

As shown in Figure 10, the general rate of application of methods by successful companies is steadily on or above the rate of underperforming companies. Detail analysis of the single method groups and their rate of application reveal the following results[1]:

1. **Basic Methods**
   An average share of the successful companies does use them. They utilize basic methods more intensively in all process phases than underperforming ones. The gap between them is constant.
2. **Statical Economic Calculation**
   A medium till high application rate is reached during concept analysis and concept validation phase. Successful companies begin to apply Statical Economic Calculation at an early stage in the process, in the idea generation phase, and use the method more intensively than underperforming ones. In concept creation phase the application rates converge.
3. **Dynamical Economic Calculation**
   Underperforming companies do not apply dynamical economic calculation at all, whereas successful companies increase the application rate – up to an average degree in concept validation and creation phases.
4. **Competition Methods**
   Obviously, successful companies have a constant medium application rate during the whole analyzed process. Underperforming companies apply competition methods the same way only in concept analysis phase. In the following two phases, the rate decreases steadily.
5. **Customer and Market Methods**
   Both types of surveyed companies, successful and underperforming, apply the methods in the idea generation phase at a medium rate. Already in concept analysis phase, the successful companies raise the rate whereas the underperformers start a steady decrease. Even in concept validation and concept creation phases, where underperforming companies do not apply customer

[1] The authors point out that the following results base on generalized data. Particular cases might differ. Furthermore, the separation between successful and underperforming companies has to be considered.

and market methods at all, successful companies still do.

6. **Strategic Methods**
Maximum application rate is medium; only in concept analysis and validation phases, a small difference in the rate appears between the successful and underperforming companies.

7. **Creativity Methods**
Both successful and underperforming companies apply creativity methods in idea generation at a high rate. The rate decreases with a high gradient and reaches low application in concept validation for both types of companies.

The interpretation of the results depicted in Figure 10 is carried out in section 5.

4.2 Innovation success vs. several strategic means

A set of different strategic means was proposed in section 2.4. The correlation between the application of these means and the innovation success of the corresponding company was another aspect of the study. Figure 11 gives an overview on the resulting correlation coefficients.

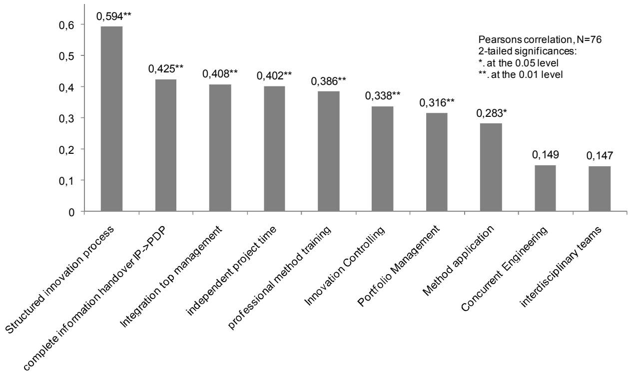


Figure 11: Correlation between innovation success and different strategic means

At first view, the positive correlation of all 10 strategic means with the innovation success is remarkable. Going into detail, 8 out of 10 means have at least significant correlation coefficients. The positive outlier with a (highly significant) correlation coefficient of nearly 0.6 is the structured innovation process. Even though this very means appeared at the top of the list in the questionnaire (see figure 5), the possible effect of the so-called rank order bias did not play a role, as both the successful and underperforming companies had of course the same list order in their questionnaires.

5 DISCUSSION AND INTERPRETATION

What characterizes the difference between successful and underperforming companies (see section 2.3) when considering the development process consisting of idea generation, concept analysis, concept validation and concept creation as discussed above?

Analyzing the results in Figure 9 and Figure 10 the most interesting topic seems to be the application of methods of dynamical economic calculation. On the one hand this method group has the most significant correlation of the examined method groups to innovation success. On the other hand Figure 10 showed that successful companies increase their application rate during the process while underperforming companies don’t use methods from this group at all. Time and effort for using such methods are normally high because a lot of influences have to be considered in this type of calculations. To allocate future expenditure and incoming payments to different periods of the lifecycle of a new product is not a trivial task. Successful companies seem to address this problem by slowly increasing the application rate of this method group during the innovation process. In the phases of concept validation and concept creation there is less uncertainty concerning technical parameters and more profound data for dynamical efficiency calculations. Furthermore the total number of projects is normally reduced in this phases because of selection processes in prior phases. Additionally the financial impact of decisions increases from phase to phase. Successful enterprises seem to choose this type of method group not without considering the benefit-cost ratio.

The results of study also indicate that successful companies in general give more thoughts about how they can systematically and method-based approach different phases of the innovation process. On average they use every observed method group like or more often than underperforming companies.
Despite the differences in the application of the several method groups the study revealed that the most significant influence to innovation success (as shown in Figure 11) is a structured innovation process. The reason of this observation could be that a structured and clearly defined innovation process is a basis for defining further steps of efficiently improving the whole innovation process. To discuss the implementation of strategic means a common understanding of the NPD processes is necessary to avoid misunderstandings. Especially to optimize interfaces between different departments or divisions a visualization of the firm's innovation process can be helpful. It can improve the communication of different participating departments and help to reduce inefficiencies of interfaces. Moreover a structured process can support the decision which kind of methods should be used in which phase or stage of an innovation process.

6 CONCLUSION

The authors introduced a measurement system to measure innovation success. A rather general approach was used for this measurement because of reasons of comparability and for getting first hints of the relevance of different possible success factors. For in-depth or more specific analysis this approach can be adapted to the specifics of companies or to particularities of industrial sectors.
On the basis of the derived index from this measurement system the influence of different possible factors have been analyzed. The results showed that the highest correlation to innovation success was the application of clearly and explicitly defined innovation processes. The study also indicated that a high degree of method application in all phases of the innovation process has positive influences to innovation success and that there are noticeable differences between successful and underperforming companies concerning the application of methods in different stages of innovation processes. Likewise the results showed that there is no single dominant influence which can be seen as surety of a successful innovation management. The possibilities to improve the innovation processes are manifold. Even if the development of a clearly defined innovation process seems to be a good starting point for the improvement of the innovation performance there is still the need for further research. Despite providing knowledge of methods and methodologies in an easy to use and practical way for companies, also a situation-depended support of choosing and adapting methods could help the industry to gain a better acceptance of the use of methods and provide better results from it.

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