What a difference a DV make ... The impact of conceptualizing the dependent variable in innovation success factor studies

Dömötör, Rudolf; Franke, Nikolaus; Hienerth, Christoph

Published in:
Journal of Business Economics (JBE) (früher: Zeitschrift für Betriebswirtschaft ZfB)

Published: 01/11/2007

Document Version
Peer reviewed version

What a Difference a DV Makes …

The Impact of Conceptualizing the Dependent Variable in Innovation Success Factor Studies

Working Paper

A later version of this paper has been published in:

Zeitschrift für Betriebswirtschaft (ZfB), Special Issue "Innovation Orientation, Innovativeness, and Innovation Success" (2/2007): 23-46.

Rudolf Dömötör
Institute for Entrepreneurship and Innovation
Vienna University of Economics and BA
Nordbergstr. 15
A-1090 Vienna
E-Mail: rudolf.doemoetoer@wu-wien.ac.at

Prof. Dr. Nikolaus Franke
Institute for Entrepreneurship and Innovation
Vienna University of Economics and BA
Nordbergstr. 15
A-1090 Vienna
E-Mail: nikolaus.franke@wu-wien.ac.at

Dr. Christoph Hienerth
Department of Industrial Economics and Strategy
Copenhagen Business School
Kilevej 14 A
DK-2000 Frederiksberg
E-Mail: ch.ivs@cbs.dk

Acknowledgements

The authors thank Jakob Grünewald and Compamedia GmbH for their valuable support.

Financial support from the WU Jubilaeumsfonds der Stadt Wien is gratefully acknowledged.

Overview

The quest for the "success factors" that drive a company's innovation performance has attracted a great deal of attention among both practitioners and academics. The underlying assumption is that certain critical activities impact the innovation performance of the company or the project. However, the findings of success factor studies lack convergence. It has been speculated that this may be due to the fact that extant studies have used many different measures of the dependent variable "innovation performance". Our study is the first to analyze this issue systematically and empirically: we analyze the extent to which different conceptualizations of the dependent variable (a firm's innovation performance) lead to different innovation success factor patterns. In order to do so, we collected data from 234 German firms, including well-established success factors and six alternative measures of innovation performance. This allowed us to calculate whether or not success factors are robust to changes in the measurement of the dependent variable. We find that this is not the case: rather, the choice of the dependent variable makes a huge difference. From this, we draw important conclusions for future studies aiming to identify the success factors in companies' innovation performance.

- Rudolf Dömötör is research assistant and doctoral candidate at the Institute for Entrepreneurship and Innovation at the Vienna University of Economics and Business AdministrationHis research interests are success factors of innovation management and entrepreneurship. www: www.e-and-i.org
- Professor Dr. Nikolaus Franke is Director of the above mentioned Institute for Entrepreneurship and Innovation. He is also Director of the TU/WU Entrepreneurship Center, Academic Director of the MBA in Entrepreneurship and Innovation (Schumpeter Program) and leads the User Innovation Research Initiative Vienna. His research areas are user innovation, toolkits for user innovation, horizontal innovation networks, and more generally entrepreneurship, innovation management, and marketing. www: www.e-and-i.org, www.userinnovation.at, www.ecvienna.at
- Dr. Christoph Hienerth is Associate Professor at the Department of Industrial Economics and Strategy, Copenhagen Business School, Kilevej 14A, 2000 Frederiksberg, and research partner at the Institute for Entrepreneurship and Innovation in Vienna. His major research interest lies in the field of user innovation. www: www.e-and-i.org, uk.cbs.dk/forskning_viden/institutter_centre/institutter/ivs

A. Introduction

What a difference a day makes …

Words & Music by Maria Grever & Stanley Adams

Sung by Dinah Washington, 1959

There is no doubt that a company's ability to generate new products and services successfully is of paramount importance to its competitive position, if not to its survival (e.g., Blundell, Griffith, & Van Reenen, 1999; Brockhoff, 1999; Capon, Farley, & Hoenig, 1990; Channey & Devinney, 1992; Christensen, Suarez, & Utterback, 1998; Clark & Fujimoto, 1991; Geroski, Machin, & Van Reenen, 1993; Hauschildt & Salomo, 2007; Urban & Hauser, 1993).

Therefore, it does not come as a surprise that the quest for the "success factors" which drive a company's innovation performance has attracted a great deal of attention among both practitioners and academics. Since the publication of the article "Why New Products Fail" by the U.S. National Industrial Conference Board in 1964 (Cochran & Thompson, 1964), over 300 academic studies on numerous potential innovation success factors have been published so far.

The underlying assumption in this line of research is that certain critical activities impact the innovation performance of a company or a project (Brown & Eisenhardt, 1995). Although it is clear from the outset that markets, technologies, and situational factors fundamentally differ between firms and that any firm's success is largely impacted by factors not under the firm's control (i.e., competitors, customers, etc.), it is assumed that the influence of these critical activities on performance follows generalizable and stable patterns.

Recently, there has been a controversial and somewhat heated debate about the value and the limitations of success factor studies (Albers & Hildebrandt 2006; Bauer & Sauer, 2004; Fritz, 2004; Homburg & Kromer, 2004; March & Sutton, 1997; Nicolai & Kieser, 2002, 2004). Several potential methodological weaknesses and shortcomings have been put forward that question the validity of such studies, and indeed the findings of success factor studies do lack convergence. In effect, this calls for studies that actually measure the impact of study design characteristics on the findings of success factor analyses.

Exemplary studies of this type are provided by Ernst (1998, 2001) as well as Albers and Hildebrandt (2006). Ernst analyzed the extent to which the function of the key informant (marketing vs. R&D and top manager vs. project manager) responding to the questionnaire impacts the success factors identified. His findings show that the function of the respondent actually moderates the findings. Albers and Hildebrandt show the influence of the proper measurement of latent constructs (reflective vs. formative) on the outcome of success factor studies. They find that many studies are based on mis-specified constructs and that the findings are biased by the use of reflective indicators where formative indicators would be more appropriate.

We contribute to this line of research by analyzing the extent to which different conceptualizations of the dependent variable, namely a firm's innovation performance (and accordingly the different measures) lead to different innovation success factor patterns. As we will demonstrate below a wide variety of measures has been used in extant studies, which gives rise to the speculation that the choice of the performance measure may be a major source of divergence in the success factors identified (Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994). However, so far this important issue has not been studied in depth. In order to do so, we collected data from 234 German firms, including 22 independent variables (which constitute 10 potential success factors) and six alternative measures of the dependent variable, namely the innovation performance of the company. This allowed us to calculate whether or not success factors are robust to changes in the measurement of the dependent variable. We find that this is not the case: rather, the choice of the dependent variable makes an enormous difference.

The remainder of this article is organized as follows: in the next section, we briefly review the relevant literature on innovation success factor studies, their problems, and the different conceptualizations of innovation performance. In Section C, we reveal the method applied in our study, and in Section D we present our findings, which we proceed to discuss in Section E.

B. Literature review

I. Success factor studies

Three particular (series of) studies can be regarded as cornerstones in the field of new product development (NPD) success research: project SAPPHO (Scientific Activity Predictor from Patterns with Heuristic Origins), project NewProd and the Stanford Innovation Project. The SAPPHO study was conducted in the United Kingdom in the early 1970s and compared 43 success and failure pairs in firms which produced chemicals and scientific instruments. The study found 41 characteristics, including understanding users’ needs, attention to the market, efficient development and senior leadership, that discriminated between success and failure (Freeman, Robertson, Achilladelis, & Jervis, 1972; Rothwell, Freeman, Horlsey, Jervis, Robertson, & Townsend, 1974). The SAPPHO study was replicated in a number of different industries and countries (e.g., Gerstenfeld, 1976; Kulvik, 1977; Rothwell, 1974; Szakasits, 1974) during the 1970s and represents the first empirical study on the antecedents of innovation performance.

The SAPPHO study was followed by Robert G. Cooper’s projects NewProd I and NewProd II (Cooper, 1979; Cooper & Kleinschmidt, 1987). NewProd I was based on empirical evidence on 102 successful and 93 failed products in 103 Canadian firms. NewProd II examined hypotheses from the first study on the basis of 203 products in 125 manufacturing firms, including 123 successes and 80 failures. It was found that innovation success is determined by three main factors: (1) the degree to which a product is unique and superior compared to existing alternatives, (2) internal organization (e.g., proficiency of the development process, preliminary technical and market assessments, top management support) and (3) market conditions.

In the Stanford Innovation Project, 70 success/failure pairs were surveyed, and 21 of them were examined in case studies (Maidique & Zirger, 1984, 1985). The authors conclude that excellent internal organization (i.e., smooth execution of all phases of the development process), product factors (i.e., provision of superior customer value) and market factors (i.e., early entry into large, growing markets) were important.

Since the 1990s, the number of academic publications on the factors which impact the success of new products saw enormous growth. Ernst (2002) found that in the period from 1994 to 1999 alone, approximately 250 success factor studies were published in academic journals. Accordingly, a number of comprehensive literature reviews (e.g., Albers, Brockhoff, & Hauschildt, 2001; Balachandra & Friar, 1997; Ernst, 2002; Van der Panne, Van Beers, & Kleinknecht, 2003) and three meta-analyses (Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994; Pattikawa, Verwaal, & Commandeur, 2006) have been published as well.

Generally, success factor studies can be classified into two different categories by the unit of analysis used in measurement: (1) success factors at the project (or product) level and (2) success factors at the program (or firm) level. Aside from this rough classification, the empirical work is characterized by substantial heterogeneity regarding the independent variables included, the (statistical) methods used, the samples drawn, and the ways in which innovation success was measured (Hauschildt, 1991). Possibly as a consequence of this heterogeneity, we find relatively different success factors in the different studies (Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994; Pattikawa et al., 2006). We present and categorize the problems and criticism regarding success factor studies in the next section.

II. Problems in success factor studies

1. General criticism

Some scholars, such as March and Sutton (1997) and Nicolai and Kieser (2002, 2005), criticize the basic idea of success factor studies. They argue that success factors lose their value once they are identified, widely known and applied. Furthermore, they argue that the findings of many studies read like a "fishing expedition" – too many variables are used to come up with a least some significant results.

Respondents to such criticism claim that this fundamental position is just like "throwing out the baby with the bath water" (e.g. Bauer & Sauer, 2004; Fritz, 2004; Homburg & Kromer, 2004). After all, "this research stream has been enormously important, particularly in creating an early and a broad understanding of which factors are essential for successful product development" (Brown & Eisenhardt, 1995: 353).

2. Content-related criticism

With regard to content (i.e., the success factors actually identified in the numerous empirical studies), Hauschildt and Salomo (2007) note the prevalence of the marketing perspective in success factor studies, whereas some presumably important organizational factors (e.g., cooperation activities) have not yet been analyzed in depth. They suppose that this imbalance may be due to the major influence of the earlier works of Cooper and Kleinschmidt, who stressed the importance of marketing-related factors in new product development.

Furthermore, it is problematic for any comparison that the sets of independent variables examined differ from study to study (van der Panne et al., 2003). Critics regard this as a lack of a profound theoretical modus operandi (Nicolai & Kieser, 2002). However, proponents maintain that an all-embracing model of innovation management simply does not exist yet (Bauer & Sauer, 2004). As a result, one can presume that the search for success factors will always be characterized by a certain amount of trial and error.

Another content-related critique refers to the question of whether all success factors fit all kinds of innovations. Several empirical studies suggest that different aspects and levels of the degree of innovativeness of a new product have to be taken into account. Whereas there seems to be a positive relationship between the market-oriented degree of innovativeness (new to the market products that offer a unique customer benefit) and innovation performance the opposite has been observed with regard to the organisation-related degree of innovativeness (new to the firm products which call for new technologies, processes, etc. in the innovating firm). Hence it is argued that different degrees of innovativeness may demand different success factors (Danneels & Kleinschmidt, 2001; Garcia & Calantone, 2002; Hauschildt, 1999; Koberg, Detienne, & Heppard, 2003; Kotzbauer, 1992; Schlaak, 1999; Salomo, Gemünden, & Billing, 2003; Salomo, Steinhoff, & Trommsdorff, 2003; Salomo, Weise, & Gemünden, 2004).

Finally, it has been put forward that success factors differ according to firm size and/or industry (De Jong & Vermeulen, 2006; Hauschildt & Salomo, 2007; Kleinknecht, 1987). As a matter of fact, most success factor studies have been conducted with samples of large industrial companies. However, additional studies involving small and medium-sized companies (De Jong & Vermeulen, 2006; Verworn, Lüthje, & Herstatt, 2000) or focusing on particular industries should be able to specify success factors for different settings.

3. Method-related criticism

a) Data collection

The majority of success factor studies are based on data from written questionnaires. It is argued that researchers seldom drew representative samples and that only a small number of studies clearly describe the sampling procedure used (Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994). Most studies rely on the willingness of respondents/companies to fill out the questionnaire. Such samples bear the risk of biases (such as self-selection biases) which may lead to an *overrepresentation of companies that are innovative* per se, because non-innovative companies are less willing to take part in a study about innovativeness (Nicolai & Kieser, 2002).

Moreover, the studies rarely account for which *person* within the organization actually filled out the questionnaire. Ernst (2001) showed that responses differ with regard to the functional (marketing vs. R&D) and hierarchical (top management vs. project management) position of a respondent. As a result, *key informant bias* is a significant moderator of variations in organizational studies.

Finally, success factor studies usually rely on *retrospective accounts* as sources of data: Respondents are asked to assess things ex post. Retrospective reports, however, may be less influenced by memory than by a reconstruction that connects standard story lines with contemporaneous results (March & Sutton, 1997). In other words, retrospective recall may create halo effects that influence a study's results (Hauschildt & Salomo, 2005). There is also a *hindsight bias:* Knowing the outcome, the input factors are recalled more positive if the project was a success, and less positive if the project was a failure. This means that the impact of the recalled success factors is overestimated.

b) Construct measurement and data analysis

Albers and Hildebrandt (2006) note that many studies adhere to the standards of reflective construct measurement, although a formative procedure would be appropriate. It has been shown that the mis-specification of latent constructs can have a substantial impact on results (Albers & Hildebrandt, 2006; Diamantopoulos & Siguaw, 2002; Jarvis, MacKenzie, & Podsakoff, 2003). Additionally, critics have pointed out that innovation success factor studies lack agreement with regard to the wording of particular items (Ernst, 2002; Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994; Pattikawa et al., 2006; van der Panne et al., 2003).

A number of different statistical methods have been used in innovation success factor studies (Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994; van der Panne et al., 2003). Basically, one should bear in mind that success factor studies aim to identify dependencies between a set of independent variables and one (or several) dependent variable(s). That should lead to the conclusion that multivariate statistics should be used, but predominantly univariate and bivariate statistics have been employed so far (Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994; van der Panne et al., 2003).

c) Dependent variable (innovation performance)

The final point refers to the different ways of assessing (degrees of) success. Many authors conjecture that the different ways of measuring innovation performance may be a source of divergent results in success factor studies with regard to variations in the magnitude and direction of effects (e.g., Hauschildt & Salomo, 2007; Henard & Szymanski, 2001; Montoya-Weiss & Calantone, 1994; Pattikawa et al., 2006; van der Panne et al., 2003). In fact, Henard and Szymanski (2001) found that multi-item versus single-item performance measures as well as subjective versus objective performance data are used in success factor studies. Theoretically, multi-item scales have the potential to enhance reliability and validity (Churchill, 1979; Griffin & Page, 1996). However, it has been shown empirically that the use of multiple indicators delivers no significant advantage in the measurement of innovation performance (Hagedoorn & Cloodt, 2003).

With regard to the source of information, it is argued that objective data (e.g., data derived from standard accounting procedures or other company records) should be more accurate and free of biases than subjective assessments, which may overstate or understate the true level of performance for a number of reasons (Henard & Szymanski, 2001).

Besides this raw classification of how innovation performance has been measured, a multitude of different performance measures can be found in success factor studies. We will address this aspect in greater detail in the next section.

III. Measuring innovation performance

What is a new product's or firm's "innovation performance"? It seems that there are different interpretations of this term, and thus numerous different indicators for innovation performance are used by scholars in the field (Cordero, 1990; Griffin & Page, 1993, 1996; Hagedoorn & Cloodt, 2003; Hollenstein, 1996).

Therefore, it is not surprising that a multitude of different innovation performance measures have been used in success factor studies. For lack of space, we refrain from presenting our own analysis of the performance measures used. Hauschildt (1991) and Ernst (2002) have already given excellent overviews on that topic. It becomes apparent that a great number of different success measures have been used, and that both single-item and multi-item performance measures are common practice. It is interesting, however, that in the majority of success factor studies the subjective assessments of managers are used, although objective data should be more accurate and free of biases. One major reason is, of course, that researchers face problems in obtaining objective data from companies for confidentiality reasons.

In addition to the success factor studies, it is worthwhile to examine the literature on (innovation) performance management and innovation performance measurement (including Brockhoff 1999; Coombs, Narandren, & Richards, 1996; Cordero, 1990; Ernst, 2001a; Flor & Oltra, 2004; Griffin & Page, 1993, 1996; Hagedoorn & Cloodt, 2003; Hauschildt, 1991; Hauschildt & Salomo, 2007; Hollenstein, 1996). Basically, the following measures have been suggested repeatedly as objective measures of economic innovation performance at the firm level (which is the unit of analysis in this study): percentage of sales from innovations, percentage of profits from innovations, number of innovations, number of patents, innovation expenditures relative to sales, and reduction of costs due to the implementation of process innovations (Table 1).

Table 1: Recommended objective innovation performance measures at the firm level

Innovation performance measures	**Recommended/used by**
Product innovation	
Percentage of sales from innovations	Bremser & Barsky, 2004; Brouwer & Kleinknecht, 1996; Cooper & Kleinschmidt, 1995; Flor & Oltra, 2004; Griffin & Page, 1993, 1996; Hollenstein, 1996; OECD-Eurostat, 2002; ZEW, 2007
Percentage of profits from innovations	Cooper & Kleinschmidt, 1995; Griffin & Page, 1993, 1996
Number of innovations	Brouwer and Kleinknecht, 1996; Coombs et al., 1996; Flor & Oltra, 2004; Hagedoorn & Cloodt, 2003; Hitt, Hoskisson, & Kim, 1997; Parthasarthy & Hammond, 2002
Number of patents	Acs & Audretsch, 1989; Archibugi, 1992; Bremser & Barsky, 2004; Ernst, 2001b; Flor & Oltra, 2004; Grupp, 1994; Hagedoorn & Cloodt, 2003; Hollenstein, 1996; Romijn & Albaladejo, 2002
Innovation expenditure (% of sales)	Bremser & Barsky, 2004; Flor & Oltra, 2004; Griliches, 1998; Hagedoorn & Cloodt, 2003; Hitt et al., 1997
Process innovation	
Cost reduction (%)	Evangelista, Sandven, Sirilli, & Smit, 1998; Myers & Marquis, 1969; OECD-Eurostat, 2002; ZEW, 2007

The first three measures are uncontroversial with regard to their ability to capture a firm's innovation performance. The problem, however, lies in varying definitions of the term "innovation". Therefore, several authors suggest differentiating between different degrees of innovativeness (e.g. improved products vs. radically new products, new to the firm products vs. new to the world products, etc.; Garcia & Calantone, 2002; OECD-Eurostat, 2002; ZEW, 2007). Another challenge regarding these measures is that they may be difficult to obtain.

The latter three require further examination. The number of patents appears to be a somewhat risky measure, as analyses have shown that the value distributions of patents are highly skewed (Harhoff, Narin, Scherer, & Vopel, 1999). Furthermore, the propensity to patent innovations varies with company size and industry (Archibugi, 1992; Griliches, 1998; Kleinknecht, 1987). Strictly speaking, the innovation budget as a percentage of sales is rather an input measure than an output (i.e., performance) measure. Both patent counts and innovation expenditure exclude the possible economic success of innovations as such. Nevertheless, they are regarded as suitable proxies for innovation performance (Acs & Audretsch, 1989; Archibugi, 1992; Ernst, 2001b; Hagedoorn & Cloodt, 2003). The percentage of cost reductions captures a different aspect of a firm's innovativeness: Basically, it refers to a firm's ability to improve efficiency on an ongoing basis. This aspect of innovation performance has not attracted a lot of attention in innovation success factor studies so far although it is recommended measure by the OECD and Eurostat (2002) and applied in the European Community Innovation Surveys (e.g. Mannheimer Innovationspanel; ZEW, 2007).

C. Method

I. Rationale of the study

In order to analyze the impact of innovation performance measurement on the success factors identified, we follow the general logic of the study conducted by Cooper and Kleinschmidt (1995) and the classification of success factors developed by Ernst (2002). This means that we basically carry out a success factor analysis of innovation performance based on extant literature in this field. However, we include different measures of the dependent variable (innovation performance), which allows us to analyze whether or not success factors are sensitive to changes in the measurement of the dependent variable.

In the study, we will follow the trend in innovation performance studies and focus on the firm level (and not the product/project level). Moreover, we follow suit with the majority of studies and include only those independent variables which are under the (at least long-term) control of the management, and we refrain from including market-related determinants of innovation performance (such as competition). Since we focus on the firm level, we will not account for product or project-related success factors such as a relative product advantage (for a comparable study design see e.g. Cooper & Kleinschmidt, 1995; Ernst, 2002).

II. Samples

Our data consists of two samples collected in 2006: (1) one random sample and (2) one purposive sample of very innovative companies. We did this in order to obtain enough variance in both the independent and the dependent variables. Excellence in innovation performance is a rare characteristic of firms; therefore, a purely random sample might contain an excessively large middle part of the distribution and not enough extreme cases, which prompted us to employ a disproportionate sampling approach (see Kalton & Anderson, 1986; Sudman, 1999; and Cefis & Marsili, 2006 for a similar approach).

As a sample of very innovative companies, we could use the unique sample of companies that have taken part in the yearly "TOP 100" competition organized by Compamedia (www.compamedia.de). The competition is open to companies in Germany with a maximum of 5,000 employees and is the largest national innovation competition based on the overall innovation management and performance of companies (as opposed to other innovation competitions that focus on the innovativeness of individual new products or services). Thus, the data allows us to analyze the characteristics of the overall company with regard to innovation performance. Among all the applications filed, we have data on those which have made it into the winning ranks (thus belonging to the top innovative companies in Germany).

The other sample was drawn from the company database KOMPASS (www.kompass.com) with a view to supplementing the TOP 100 data. That means that sample selection was based on the objective of structural congruence with the TOP 100 data. Accordingly, the companies in our convenience sample and in our random sample do not differ with regard to firm characteristics such as size (number of employees, turnover) and industry (manufacturing vs. services sector). A total of 1,900 companies were contacted via e-mail and invited to fill out an online questionnaire in March 2006. 0.95% of the e-mail-addresses were invalid. After sending out three reminders to take part in our study over a period of six weeks, we had a final sample comprising data from 120 companies, which indicates a very moderate response rate of 6.4%. Although we could not detect any indicator of non-response bias within our sample (based on procedures suggested by Armstrong & Overton, 1977), we cannot claim full representativeness. However, the objective of this study is not to identify generalizable success factors but to analyze their robustness, an objective which does not necessarily depend on the representativeness of the data used.

The questionnaires were addressed to the companies' CEOs. Our data indicate that 96% of the questionnaires were actually completed by general managers. Thus we assume that key informant bias may not be an issue in our data (Ernst, 2001a; Ernst & Teichert, 1998). Participants were assisted in completing the questionnaire by a 25-pages instruction booklet in which all the items in our questionnaire were described in detail. In addition, we thoroughly examined the raw data and contacted respondents as necessary in order to verify implausible or surprising values. In sum, 104 companies were contacted by e-mail and/or telephone to improve the reliability of our data.

Our final data set comprises 234 companies. The elimination of cases with missing values led to a final number of 186 companies, with 100 belonging to the sample of top innovative performers and 86 belonging to the second sample of "standard" companies.

III. Measurement

1. Independent variables

As the study aims to test the robustness of success factors in typical studies on innovation performance, the selection of independent variables is based strictly on the existing literature. We focus on five categories of success factors that are either process or organization-related and can therefore be influenced by management: (1) NPD process, (2) organization, (3) culture, (4) role and commitment of senior management and (5) strategy. This classification is in line with that of Cooper and Kleinschmidt (1995) and Ernst (2002).

The first part (**NPD process**) covers aspects of the innovation process and includes three variables: the *level of stage-specific effort* visible in the process of NPD projects (an index of seven variables that describe the organization of different stages of the NPD process, ranging from the evaluation of ideas to acceptance testing before market entry; Barczak, 1995;

Calantone, Schmidt, & Di Benedetto, 1997; Cooper & Kleinschmidt, 1986, 1993, 1995; De Brentani, 1988; Dwyer & Mellor, 1991a, 1991b; Griffin, 1997; Mishra, Kim, & Lee, 1996; Parry & Song, 1994). The second and third variables refer to the market orientation of the NPD process: *monitoring* (a dummy indicating whether a firm has a separate monitoring department or not) and *involvement of the marketing department* in innovation projects (Atuahene-Gima, 1995; Calantone & Di Benedetto, 1988; Cooper, 1983; Cooper & Kleinschmidt, 1995, 1996; De Brentani, 1989; Kotzbauer, 1992; Mishra et al., 1996; Parry & Song, 1994; Rubenstein, Chakrabarti, O'Keefe, Souder, & Young, 1976).

The second part deals with the **organization** and includes an internal and an external component. External organization is the extent of *cooperation activities* (an index of cooperation with customers, suppliers, competitors, universities, and research centers) (Freel, 2005; Gemünden, Heydebreck, & Herden, 1992; Iansiti, 1997). Internal organization refers to the employment of *project management and controlling* (an index of the two variables "use of systematic project management" and "use of project controlling") (Balachandra, Brockhoff, & Pearson, 1996; Barczak, 1995; Johne, 1984; Larson & Gobeli, 1988).

The third part is the innovative **culture**. We measure the existence of a formalized *incentive system* for innovative activities (included as a dummy variable) (Cooper, Edgett, & Kleinschmidt, 2004; Cooper & Kleinschmidt, 1995; Leenders & Wierenga, 2002), *training activities* (measured by the number of training days per employee) (Cooper, 1999; Flor & Oltra, 2004; Freel, 2005) and the existence of *promotors* (or champions) in innovation projects (Barczak, 1995; Iansiti, 1997; Maidique & Zirger, 1984; Song & Parry, 1997; Yap & Souder, 1994).

The next category refers to the **role and commitment of senior management**, which is an index of the two variables "definition of innovation goals" and "controlling innovation process" by senior management (Baker, Green, & Bean, 1986; Balachandra, 1984; Cooper et al., 2004; Cooper & Kleinschmidt, 1993; Gerstenfeld, 1976; Johne & Snelson, 1988; Kotzbauer, 1992; Maidique & Zirger, 1984; Song & Parry, 1997; Thamhain, 1990).

Finally, in order to reflect the **strategy** of the company, we use *expenditures for innovative activities* as a percentage of sales (Balbontin, Yazdani, Cooper, & Souder, 1999; Cooper et al., 2004; Cooper & Kleinschmidt, 1995; OECD-Eurostat, 2002; Schmalen & Wiedemann, 1999; Thamhain, 1990; Voss, 1985). A more detailed overview of the variables and indices used is provided in the Appendix.

2. Dependent variables

In our study, we focus on *objective* innovation performance measures (i.e., data that does not rely on the subjective assessment of the respondent), especially as the study conducted by Ernst (2001) already showed that the subjective perception of key informants in the companies has an impact on findings, thus there is no need to replicate that study.

Our set of dependent variables covers the most frequently used objective measures to capture the innovation performance of companies. We use a total of six variables: The first is the percentage of turnover generated by innovations introduced on the market within the past three years (e.g., as employed by Bremser & Barsky, 2004; Brouwer & Kleinknecht, 1996; Cooper & Kleinschmidt, 1995; Flor & Oltra, 2004; Griffin & Page, 1993, 1996; Hollenstein, 1996; OECD-Eurostat, 2002). The second is the percentage of profits achieved with innovations marketed within the past three years (e.g., as employed by Cooper & Kleinschmidt, 1995; Griffin & Page, 1993, 1996). Then we use the total number of innovations marketed by the company within the past three years (e.g., as employed by Brouwer & Kleinknecht, 1996; Coombs et al., 1996; Flor & Oltra, 2004; Hagedoorn & Cloodt, 2003; Hitt et al., 1996; Parthasarthy & Hammond, 2002). "Innovation" in our study refers to both radical innovation (i.e., new to the world) and incremental innovation (i.e., major improvements to existing products). This understanding is in line with the definitions provided by the OECD in the Frascati Manual (2002).

The fourth variable we focus on is process innovations. This aspect is measured by the percentage of costs saved (reduced) within one year by implementing process innovations (e.g., as employed by Evangelista et al., 1998; Myers & Marquis, 1969; OECD-Eurostat, 2002). The fifth measure is the number of patents granted in the three years prior to data collection (e.g., as employed by Acs & Audretsch, 1989; Archibugi, 1992; Bremser & Barsky, 2004; Ernst, 2001b; Flor & Oltra, 2004; Grupp, 1994; Hagedoorn & Cloodt, 2003; Hollenstein, 1996; Romijn & Albaladejo, 2002). Finally, we include a variable which has been used as an output measure as well as an input measure: expenditures for innovative activities relative to sales (e.g., as employed by Bremser & Barsky, 2004; Flor & Oltra, 2004; Griliches, 1998; Hagedoorn & Cloodt, 2003; Hitt et al., 1997; OECD-Eurostat, 2002). The questionnaire had been successfully pretested, and also successfully used for the TOP 100 competition in the years prior to 2006.

D. Findings

I. Bivariate analyses

In a first step, we analyze the extent to which our two samples of companies differ with regard to the independent variables (i.e., potential success factors) and the dependent variables (i.e., measures of innovation performance). Clear differences in the variables of both groups not only show the correctness of our sampling approach (one highly innovative sample of TOP 100 companies and one "normal" sample of non-TOP 100 companies), but they also yield initial insights into the appropriateness of the term "success factors".

Table 2: Mean comparisons (TOP 100 companies vs. non-TOP 100 companies)

Characteristics	TOP 100[a]	Non TOP 100[b]	Difference (P-value)[c]
NPD Process			
Stage-specific effort	4.57 (.41)	3.77 (.77)	<0.000
Monitoring (dummy)	.61	.32	<0.000
Involvement of marketing dept.	39.89 (24.11)	18.48 (15.64)	<0.000
Organization			
Cooperation activities	3.86 (.58)	3.22 (.83)	<0.000
Project management & controlling	4.78 (.39)	3.79 (1.11)	<0.000
Innovative Culture			
Formalized incentive system (dummy)	.85 (.36)	.50 (.50)	<0.000
Training activities	7.4 (4.9)	4.4 (3.3)	<0.000
Promotors	4.88 (.38)	4.18 (1.12)	<0.000
Senior Management			
Commitment	4.86 (.34)	4.33 (.79)	<0.000
Strategy			
Innovation expenditures (% of sales)	11.19 (19.56)	7.98 (13.33)	n.s.
Control variables			
Size (employees)	454 (985)	323 (1042)	n.s.
Industry (manuf. sector dummy)	.65	.67	n.s.
Performance measures			
Turnover from innovations (%)	66.61 (24.64)	30.20 (23.72)	<0.000
Profits from innovations (%)	69.73 (23.63)	33.39 (27.30)	<0.000
Number of innovations	37.0 (64.0)	16.5 (41.6)	<0.05
Process innovations (% cost reductions)	12.84 (10.24)	5.99 (5.86)	<0.000
Number of patents	22.9 (72.6)	12.5 (79.5)	n.s.
Innovation expenditures (% of sales)	11.19 (19.56)	7.98 (13.32)	n.s.

[a] All values are means, n=100; [b] All values are means; n=86; [c] Two-tailed t-tests for independent samples; * dichotomous scale; **days/year; all other characteristics (five-point rating scale)

We find highly significant differences between the two groups in both independent and dependent variables (Table 2). This is a first indication that the success factors are, in fact, somewhat related to the innovation performance of the companies. The only exceptions are expenditures for innovation and the number of patents, where differences are not significant due to one outlier in the non-TOP 100 sample (when the outlier is omitted, the difference becomes significant at $p<0.01$ and is in the expected direction). The standard deviations in the samples are relatively high, which prompts us to pool the data for further analyses.

In the next step, we analyze the extent to which the dependent variables are correlated. If they are interchangeable measures of innovation performance, we should expect high correlations between them.

Table 3: Correlation analyses of dependent variables

Innovation performance measure	1	2	3	4	5
1 Turnover from innovations (%)					
2 Profits from innovations (%)	.90**				
3 Number of innovations	.07	.03			
4 Process innovations[a]	.37**	.38**	.02		
5 Number of patents	-.10	-.12	.24**	-.07	
6 Innovation expenditures (%)	.27**	.26**	.03	.14	-.04

*p<0.05, **p<0.01; [a] cost reduction in %

The results are highly revealing (Table 3). While the percentage of turnover generated by innovations, the percentage of profits generated by innovations, expenditures for innovative activities relative to sales, and the percentage of costs saved by process innovations show significant positive pairwise correlations, the other two variables (total number of innovations and the number of patents granted) appear to measure something completely different. A very low Cronbach's alpha of .297 confirms that the six measures are not interchangeable. This suggests that the factors which foster the performance visible in these measures (i.e., success factors) might also differ.

II. Multivariate analysis

The main finding of this study lies in our multivariate analysis of the relationship between independent and dependent variables. We estimate six OLS regression models, each containing all of the independent variables and a different measure of the company's innovation performance. Only model 6 differed in one respect: here, we took Innovation expenditures (% of sales) as the dependent variable, and hence excluded it from the list of independent variables. If the success factors are robust to the measurement of the dependent variable, we should observe identical significance patterns in the different models.

However, the overall result of the OLS regressions clearly shows the opposite (Table 4). The choice of the dependent variable impacts the significance structure of the independent variables. While Model 1 (DV = percentage of turnover generated by innovations) and Model 2 (DV = percentage of profits generated by innovations) are relatively similar, and Model 4 (DV = percentage of costs saved by process innovations) and Model 6 (DV = expenditures for innovative activities relative to sales) are at least somewhat related, the other two tell a completely different story. *In other words, the success factors for company innovation performance identified by means of typical success factor studies are indeed dependent on the measures used for innovation performance.*

Apart from this, our findings from the t-tests are confirmed in this analysis. It appears that the overall variance in each dependent variable is at least to some degree explained by the set of independent variables, that is, the success factor candidates. The R^2 of most models is substantial, and overall the models are significant (with the exception of model 6).

Table 4: Regression models with different innovation performance measures

Independent Variables	Model (1) DV = Turnover from innovations (%)	(2) DV = Profits from innovations (%)	(3) DV = Number of innovations	(4) DV = Process innovations[a]	(5) DV = Number of patents	(6) DV = Innovation expenditures (%)
NPD Process						
Stage-specific effort	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
Monitoring (dummy)	n.s.	n.s.	n.s.	n.s.	.15 (12.00)*	n.s.
Involvement of marketing dept.	.21 (.09)**	.17 (.10)*	n.s.	n.s.	n.s.	.12 (.06)[†]
Organization						
Cooperation activities	n.s.	n.s.	.15 (7.78)[†]	n.s.	n.s.	n.s.
Project management & controlling	n.s.	n.s.	n.s.	.16 (1.52)[†]	n.s.	n.s.
Innovative Culture						
Formalized incentive system (dummy)	n.s.	n.s.	n.s.	.13 (1.71)[†]	n.s.	n.s.
Training activities	.28 (.50)***	.22 (.53)**	n.s.	.28 (.17)**	n.s.	n.s.
Promotors	.17 (3.26)*	.16 (3.50)*	n.s.	n.s.	n.s.	.15 (2.12)[†]
Senior Management						
Commitment	.11 (4.22)[†]	n.s.	n.s.	n.s.	n.s.	n.s.
Strategy						
Innovation expenditures (% of sales)	.21 (.12)**	.18 (.14)**	n.s.	n.s.	n.s.	-
Control variables						
Size (employees)	n.s.	-.13(1.50)*	.26 (3.04)**	-.15 (.46)*	.39 (4.00)***	-.23 (.87)**
Industry (manuf. sector dummy)	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
R	.60	.56	.40	.50	.47	.32
R^2	.36	.31	.16	.25	.22	.10
R^2 corr.	.31	.26	.09	.19	.16	.04
F	7.19***	5.96***	2.45**	4.25***	3.580***	n.s.

[†] p<.10 (one-tailed test), * p<.05 (one-tailed test), ** p<.01 (one-tailed test), *** p<.001 (one-tailed test), values shown are standardized coefficients (beta), standard errors in brackets, n = 166, [a] cost reductions as %

E. Discussion

Our findings on the robustness of success factors in innovation performance are somewhat disturbing. Had we, for example, only used the number of patents granted as the dependent variable in a success factor analysis, our conclusion would be that the only clear driver of a company’s innovation performance is the existence of a monitoring department. On the other hand, if we had used the percentage of profits generated by innovations as the dependent variable, our conclusions would be completely different: we would presume that such a monitoring department is of no use, and instead we should facilitate innovation promotors, invest in training activities for employees, involve the marketing department in innovation processes and generally invest more resources in innovation. These conclusions are conflicting and deeply question the conclusions drawn by success factor studies.

What does this mean?

First of all, the findings of success factor studies with different dependent variables are not directly comparable, as they obviously measure different things. Second, as these variables are not interchangeable, their antecedents (i.e., success factors) clearly differ and the managerial conclusions derived from the findings conflict, it appears to be of paramount importance to assess their appropriateness for capturing a company’s innovation performance. From a management perspective, there are clear arguments for using the measures "percentage of turnover generated by innovations" and "percentage of profits generated by innovations", as innovative activity is ultimately not an end in itself but has to serve economic objectives. On the other hand, one must bear in mind that these measures are relative, and that a high innovation performance expressed in them does not necessarily mean that the company is successful overall. For example, let Company A have a profit of 1 million euros with 80% resulting from innovations, and Company B a profit of 30 million euros with 50% from innovations. Can we conclude that Company A has a higher innovation performance because 80% is higher than 50%? After all, A’s profit due to innovation is only 800,000 euros, while B’s profit due to innovation is 15 million. Comparable arguments can also be made against the other measures. It is clear from the outset that measuring a company’s performance using the number of innovations, patents granted or R&D expenditures is problematic a fortiori, despite the relatively high availability of these measures. Our conclusion is that innovation performance is a multi-faceted construct which cannot be captured in a single variable without the concrete danger of limited validity. Presumably, this construct is formative (and not reflective) in nature, and possibly only such constructs should be used in success factor analysis. However, further research – both conceptual and empirical – on this topic appears to be necessary.

In addition, our study suffers from certain methodological limitations which constitute opportunities for future research. As usual in success factor studies, our samples are not free of biases, their size is relatively small, and due to questionnaire length limitations we were not able to include all (independent) variables that might have an impact on a company's innovation performance. Nevertheless, we strongly believe that these shortcomings do not impact our main findings.

Finally, our findings should not be read as a destructive critique of success factor studies which focus on innovation performance. The next lines in the song "What a difference a day makes", which we borrowed for the title of this article, are "There's a rainbow before me, skies above can't be stormy", and this points to the positive idea that our findings again suggest that there is a set of factors that distinguishes innovative from less innovative companies. Despite the different structures of the models, the R^2 is substantial, and also the bivariate analysis shows that companies with high innovation output (however measured) are structurally different from less innovative companies. Presumably, the causality is much more complicated than in our simple OLS model; there may be numerous interactions, non-linearities, delay effects, and many situation-specific moderators. Still, we find that innovation performance is not the result of a game of chance, but the outcome of systematic innovation management.

Summary

- The quest for the “success factors” that drive a company’s innovation performance has attracted a great deal of attention among both practitioners and academics in the past 40 years. The underlying assumption is that certain critical activities impact the innovation performance of the company or the project. The findings of success factor studies, however, lack convergence. Among other reasons it has been speculated that this may be due to the fact that extant studies have used many different measures of the dependent variable “innovation performance”.
- Our study is the first to analyze this issue systematically and empirically: we analyze the extent to which different conceptualizations of the dependent variable (a firm’s innovation performance) lead to different innovation success factor patterns. In order to do so, we collected data from 234 German firms, including well-established success factors and six alternative measures of innovation performance. This allowed us to calculate whether or not success factors are robust to changes in the measurement of the dependent variable.
- We find that this is not the case: rather, the choice of the dependent variable makes a huge difference. From this, we draw important conclusions for future studies aiming to identify the success factors in companies’ innovation performance.

Zusammenfassung

- Die Suche nach so genannten “Erfolgsfaktoren”, also Unternehmensmerkmalen, die den Innovationserfolg eines Unternehmens bestimmen, wurde in den letzten vierzig Jahren intensiv betrieben. Die dieser Forschungsrichtung zugrunde liegende Annahme ist, dass bestimmte kritische Aktivitäten den Innovationserfolg eines Unternehmens oder eines Projekts beeinflussen. Die Ergebnisse bisheriger Studien zeigen jedoch eine nur mäßige Konvergenz. Es wird verschiedentlich gemutmaßt, dass dieser irritierende Befund im Gebrauch unterschiedlicher Messkonzepte für die abhängige Variable (den Innovationserfolg) begründet sein könnte.
- Die vorliegende Studie ist die erste, die diese Vermutung systematisch empirisch untersucht. Es wird analysiert, inwieweit unterschiedliche Messkonzepte der abhängigen Variable (d.h. des Innovationserfolgs) zu unterschiedlichen Erfolgsfaktorenmustern führen. Hierzu wurden Daten von 234 deutschen Unternehmen gesammelt, wobei in der Literatur etablierte Erfolgsfaktoren als

unabhängige und sechs alternative Messkonzepte des Innovationserfolgs als jeweils abhängige Variable herangezogen wurden.

- Im Ergebnis zeigt sich, dass die Wahl der abhängigen Variable das Ergebnis stark beeinflusst. Je nach gewähltem Maß des Innovationserfolges ergeben sich völlig unterschiedliche Erfolgsfaktoren. Aus diesem Befund werden wichtige Folgerungen für die weitere Erfolgsfaktorenforschung gezogen.

References

Acs, Z.J., & Audretsch, D.B. 1989. Patents as a measure of innovative activity. Kyklos, 4: 171-180.

Albers, S., Brockhoff, K., & Hauschildt, J. 2001. **Technologie- und Innovationsmanagement**. Leistungsbilanz des Kieler Graduiertenkollegs: Wiesbaden.

Albers, S., & Hildebrandt, L. 2006. Methodische Probleme bei der Erfolgsfaktorenforschung - Messfehler, formative versus reflektive Indikatoren und die Wahl des Strukturgleichungs-Modells. **Zeitschrift für Betriebswirtschaft (ZfB)**, 58 (1): 2-33.

Archibugi, D. 1992. Patenting as an indicator of technological innovation: A review. **Science and Public Policy**, 19 (6): 357-358.

Armstrong, S., & Overton, T. 1977. Estimating nonresponse bias in mail surveys. **Journal of Marketing Research**, 14 (3): 396-402.

Atuahene-Gima, K. 1995. An exploratory analysis of the input of market orientation on new product performance. A contingency approach. **Journal of Product Innovation Management**, 12 (4): 275-293.

Baker, N.R., Green, S.G., & Bean, A.S. 1986. Why R&D projects succeed or fail. **Research Technology Management**, 29(6): 29-34.

Balachandra, R. 1984. Critical signals for making go/nogo decisions in new product development. **Journal of Product Innovation Management**, 1 (2): 92-100.

Balachandra, R., Brockhoff, K., & Pearson, A.W. 1996. R&D project termination decisions: processes, communication, and personnel changes. **Journal of Product Innovation Management**, 13 (3): 245-256.

Balachandra, R., & Friar, J.H. 1997. Factors for success in R&D projects and new product innovation: a contextual framework. **IEEE Transactions in Engineering Management**, 44 (3): 276-287.

Balbontin, A., Yazdani, B., Cooper, R.G., & Souder, W.E. 1999. New product development success factors in American and British firms. **International Journal of Technology Management**, 17 (3): 259-279.

Barczak, G. 1995: New product strategy, structure, process, and performance in the telecommunications industry. **Journal of Product Innovation Management**, 12 (3): 224-234.

Bauer, H.H. & Sauer, N.E. 2004. Die Erfolgsfaktorenforschung als schwarzes Loch. **Die Betriebswirtschaft (DBW)**, 64(4): 631-633.

Blundell, R. Griffith, R., & Van Reenen, J. 1999. Market share, market value and innovation in a panel of British manufacturing firms. **Review of Economic Studies**, 66 (3): 529-554.

Bremser, W.G., & Barsky, N.P. 2004. Utilizing the balanced scorecard for R&D performance measurement. **R&D Management**, 34 (3): 229-238.

Brockhoff, K. 1999. **Produktpoliti**k. Stuttgart: UTB.

Brouwer, E., & Kleinknecht, A. 1996. Determinants of innovation output. A microeconometric analysis of three innovation output indicators, in: Kleinknecht, A. (Ed.), **Determinants of Innovations: The Message from New Indicators**: 99-124: London: Macmillan.

Brown, S.L., & Eisenhardt, K.M. 1995. Product development: Past research, present findings, and future directions. **The Academy of Management Review**, 20 (2): 343-378.

Calantone, R.J., & di Benedetto, C.A. 1988. An integrative model of the new product development process. **Journal of Product Innovation Management**, 5 (3): 201-215.

Calantone, R.J., Schmidt, J.B., & di Benedetto, C.A. 1997. New product activities and performance: the moderating role of environmental hostility. **Journal of Product Innovation Management**, 14 (3): 179-189.

Capon, N. Farley, J.U., & Hoenig, S. 1990. Determinants of financial performance: a meta-analysis. **Management Science**, 36 (10): 1143-1159.

Cefis, E., & Marsili, O. 2006. Survivor: The role of innovation in firm's survival. **Research Policy**, 35 (5): 626-641.

Chaney, P.K., & Devinney, T.M. 1992. New product innovations and stock price performance. **Journal of Business, Finance and Accounting**, 19 (5): 677-695.

Christensen, C., Suarez, F., & Utterback, J. 1998. Strategies for Survival in Fast-Changing Industries. **Management Science**, 44 (12): 207-220.

Churchill, G.A. 1979. A paradigm for developing better measures of marketing constructs. **Journal of Marketing**, 16 (1): 64-73.

Clarke, K.B., & Fujimoto, T. 1991. **Product development performance**. Boston: Harvard Business School Press.

Cochran, B., & Thompson, G. 1964. **Why new products fail**. The National Industrial Conference Board Record: 11-18.

Coombs, R., Narandren, P., & Richards, A. 1997. A literature-based innovation output indicator. **Research Policy**, 25(4): 403-413.

Cooper, R.G. 1979. The dimensions of industrial new product success and failure. **Journal of Marketing**, 43 (3): 93-103.

Cooper, R.G. 1983. The impact of new product strategies. Industrial Marketing Management, 12 (4): 243-256.

Cooper, R.G. 1999. From experience: The invisible success factors in product innovation. **Journal of Product Innovation Management**, 16 (2): 115-133.

Cooper, R.G., Edgett, S.J., & Kleinschmidt, E.J. 2004a. Benchmarking best NPD practices – I. **Research Technology Management**, 47(1): 31-43.

Cooper, R.G., Edgett, S.J., & Kleinschmidt, E.J. 2004b. Benchmarking best NPD practices – II. **Research Technology Management**, 47(3): 50-59.

Cooper, R.G., Edgett, S.J., & Kleinschmidt, E.J. 2004c. Benchmarking best NPD practices – III. **Research Technology Management**, 47(6): 43-55.

Cooper, R.G., & Kleinschmidt, E.J. 1986. An investigation into the new product process: steps, deficiencies and impact. **Journal of Product Innovation Management**, 3 (2): 71-85.

Cooper, R.G., & Kleinschmidt, E.J. 1987. New products: What separates winners from losers? **Journal of Product Innovation Management**, 4 (3): 169-184.

Cooper, R.G., & Kleinschmidt, E.J. 1993. Major new products: What distinguishes the winners in the chemical industry? **Journal of Product Innovation Management**, 10 (2): 90-111.

Cooper, R.G., & Kleinschmidt, E.J. 1995. Benchmarking the firm's critical success factors in new product development. **Journal of Product Innovation Management**, 12 (5): 374-391.

Cooper, R.G., & Kleinschmidt, E.J. 1996. Winning businesses in product development. The critical success factors. **Research Technology Management**, 39 (4): 18-29.

Cordero, R. 1990. The measurement of innovation performance in the firm: An overview. **Research Policy**, 19 (2): 185-192.

Danneels, E., & Kleinschmidt, E.J. 2001. Product innovativeness from the firm's perspective: Its dimensions and their relation with project selection and performance. **Journal of Product Innovation Management**, 18 (6): 357-373.

De Brentani, U., & Dröge, C. 1988. Determinants of the new product screening decision. A structural model analysis. **International Journal of Research in Marketing**, 5 (2): 91-106.

De Jong, J.P.J., & Vermeulen, P.A.M. 2006. Determinants of product innovation in small firms. **International Small Business Journal**, 24(6): 587-609.

Diamantopoulos, A., & Siguaw, J.A. 2002. **Formative vs. reflective indicators in measure development: Does the choice of indicators matter?** Working Paper, Cornell School of Hotel Administration.

Dwyer, L., & Mellor, R. 1991a. Organizational environment, new product process activities, and project outcomes. Journal of Product Innovation Management, 8 (1): 39-48.

Dwyer, L., & Mellor, R. 1991b. New product process activities and project outcomes. **R&D Management**, 21 (1): 31-42.

Ernst, H. 2001a. **Erfolgsfaktoren neuer Produkte. Grundlagen für eine valide empirische Forschung**. Wiesbaden: Deutscher Universitätsverlag.

Ernst, H. 2001b. Patent applications and subsequent changes of performance: evidence from time-series cross-section analyses on the firm level. **Research Policy**, 30 (1): 143-157.

Ernst, H. 2002. Success factors of new product development: a review of the empirical literature. **International Journal of Management Reviews**, 4(1): 1-40.

Ernst, H., & Teichert, T. 1998. The R and D/Marketing interface and single informant bias in NPD research: An illustration of a benchmarking case study. **Technovation**, 18: 721-739.

Evangelista, R., Sandven, T., Sirilli, G., & Smith, K. 1998. Measuring Innovation in European Industry. **International Journal of the Economics of Business**, 5 (3): 311-333.

Flor, M.L., & Oltra, M.J. 2004. Identification of innovating firms through technological innovation indicators: An application to the Spanish ceramic tile industry. **Research Policy**, 33 (2): 323-336.

Freel, M.S. 2005. Patterns of innovation and skills in small firms. **Technovation**, 25 (2): 123-134.

Freeman, C. Robertson, A.B., Achilladelis, B.G., & Jervis, P. 1972. **Success and failure in industrial innovation, Report on Project SAPPHO by the Science Policy Research Unit**. London: Center for the Study of Industrial Innovation, University of Sussex.

Fritz, W. 2004. **Über Tautologien, gesicherte Erkenntnisse und ein problematisches Wissenschaftsverständnis.** Arbeitspapier Nr. 04/06, Technische Universität Braunschweig.

Garcia, R., & Calantone, R. 2002. A critical look at technological innovation typology and innovativeness terminology: A literature review. **Journal of Product Innovation Management**, 19 (2): 110-132.

Gemünden, H.G., Heydebreck, P., & Herden, R. 1992. Technological interweavement: A means of achieving innovation success. **R&D Management**, 22 (4): 359-375.

Geroski, P., Machin, S., & Van Reenen, J. 1993. The profitability of innovating firms. **RAND Journal of Economics**, 24 (2): 198-211.

Gerstenfeld, A. 1976. A study of successful projects, unsuccessful projects and projects in process in West Germany. **IEEE Trasactions in Engineering Management**, 23: 116-123.

Griffin, A. 1997. PDMA research on new product development practices: Updating trends and benchmarking best practices. **Journal of Product Innovation Management**, 14 (6): 429-458.

Griffin, A., & Page, A.L. 1993. An interim report on measuring product development success and failure. **Journal of Product Innovation Management**, 10 (4): 291-308.

Griffin, A., & Page, A.L. 1996. PDMA success measurement project: Recommended measures for product development success and failure. **Journal of Product Innovation Management**, 13 (6): 478-496.

Griliches, Z. 1998. **R&D and productivity: The econometric evidence**. The University of Chicago Press, Chicago.

Grupp, H. 1994. The measurement of technical performance of innovations by technometrics and its impact on established technology indicators. **Research Policy**, 23 (2): 175-193.

Hagedoorn, J., & Cloodt, M. 2003. Measuring innovative performance: is there an advantage in using multiple indicators? **Research Policy**, 32 (8): 1365-1379.

Harhoff, D., Narin, F., Scherer, F.M., & Vopel, K. 1999. Citation frequency and the value of patented innovation, **Review of Economics and Statistics**, 81(3): 511-515.

Hauschildt, J. 1991. Zur Messung des Innovationserfolgs. **Zeitschrift für Betriebswirtschaft (ZfB)**, 61: 451-476.

Hauschildt, J. 1999. Widerstand gegen Innovationen – destruktiv oder konstruktiv? **Zeitschrift für Betriebswirtschaft (ZfB), 2 (Ergänzungsheft)**: 1-21.

Hauschildt, J., & Salomo, S. 2005. Je innovativer, desto erfolgreicher? Eine kritische Analyse des Zusammenhangs zwischen Innovationsgrad und Innovationserfolg. **Journal für Betriebswirtschaft**, 55(1): 3-20.

Hauschildt, J., & Salomo, S. 2007. **Innovationsmanagement**. München: Vahlen.

Henard, D.H., & Szymanski, D.M. 2001. Why some new products are more successful than others. **Journal of Marketing Research**, 38 (3): 362-375.

Hitt, M.A., Hoskisson, R.E., & Kim, H. 1997. International diversification: Effects on innovation and firm performance in product-diversified firms. **Academy of Management Journal**, 40 (4): 767-798.

Hollenstein, H. 1996. A composite indicator of a firm's innovativeness. An empirical analysis based on survey data for Swiss manufacturing. **Research Policy**, 25 (4): 633-645.

Homburg, C., & Kromer, H. 2004. **Die Fliegenpatsche als Instrument des wissenschaftlichen Dialogs**, Wissenschaftliches Arbeitspapier Nr. W74, Universität Mannheim.

Iansiti, M. 1997. From technological potential to product performance: An empirical analysis, **Research Policy**, 26 (3): 345-366.

Jarvis, C.B., MacKenzie, S.B., & Podsakoff, P.M. 2003. A critical review of construct indicators and measurement model misspecifications in marketing and consumer research. **Journal of Consumer Research**, 30 (2): 199-218.

Johne, F.A. 1984. How experienced product innovators organize. **Journal of Product Innovation Management**, 1 (4): 210-223.

Johne, F.A., & Snelson, P.A. 1988. Success factors in product innovation: A selective review of the literature. **Journal of Product Innovation Management**, 5 (2): 114-128.

Kalton, G., & Anderson, D.W. 1986. Sampling Rare Populations. **Journal of the Royal Statistical Society,** 149 (1): 65-82.

Kieser, A., & Nicolai, A. 2005. Success Factor Research: Overcoming the Trade-Off Between Rigor and Relevance? **Journal of Management Inquiry**, 14 (3): 275-279.

Kleinknecht, A. 1987. Measuring R&D in small firms: How much are we missing? **Journal of Industrial Economics**, 36 (2): 253-256.

Koberg, C.S., Detienne, D.R., & Heppard, K.A. 2003. An empirical test of environmental, organizational, and process factors affecting incremental and radical innovation. **Journal of High Technology Management Research**, 14 (1): 21-45.

Kotzbauer, N. 1992. **Erfolgsfaktoren neuer Produkte: Der Einfluss der Innovationshöhe auf den Erfolg technischer Produkte**. Frankfurt am Main: Verlag Peter Lang.

Kulvik, H. 1977. **Factors underlying the success and failure of new products**. Report No. 29, Helsinki, Finland: University of Technology.

Larson, E.W., & Gobeli, D.H. 1988. Organizing for product development projects. **Journal of Product Innovation Management**, 5 (3): 180-190.

Leenders, M.A., & Wierenga, B. 2002. The effectiveness of different mechanisms for integrating marketing and R&D. **Journal of Product Innovation Management**, 19 (4): 305-317.

Maidique, M.A., & Zirger, B. 1984. A study of success and failure in product innovation: The case of the U.S. electronics industry. **IEEE Transactions in Engineering Management**, 4: 192-203.

Maidique, M.A., & Zirger, B. 1985. The new product learning cycle. **Research Policy**, 14 (6): 299-313.

March, J.G., & Sutton, R.I. 1997. Organizational performance as a dependent variable. **Organization Science**, 8 (6): 698-706.

Mishra, S., Kim, D., & Lee, D.H. 1996. Factors affecting new product success: cross-country comparisons. **Journal of Product Innovation Management**, 13 (6): 530-550.

Montoya-Weiss, M.M., & Calantone, R. 1994. Determinants of new product performance: A review and meta-analysis. **Journal of Product Innovation Management**, 11 (5): 397-417.

Myers, S., & Marquis, D.G. 1969. **Successful industrial innovations**. National Science Foundation.

Nicolai, A., & Kieser, A. 2002. Trotz eklatanter Erfolglosigkeit: Die Erfolgsfaktorenforschung weiter auf Erfolgskurs. **Die Betriebswirtschaft (DBW)**, 62 (6): 579-596.

Nicolai, A., & Kieser, A. 2004 Von Konsensgenerierungsmaschinen, Nebelkerzen und „the Operation called verstehen". **Die Betriebswirtschaft**, 64 (7): 631-635.

OECD-Eurostat 2002. **The measurement of scientific and technological activities. Proposed guidelines for collecting and interpreting technological innovation data (Oslo-Manual)**. Paris.

Parry, M.E., & Song, X.M. 1994. Identifying new product success in China. **Journal of Product Innovation Management**, 11 (1): 15-30.

Parthasarthy, R., & Hammond, J. 2002. Product innovation input and outcome: Moderating effects of the innovation process. **Journal of Engineering and Technology Management**, 19 (1): 75-91.

Pattikawa, L.H., Verwaal, E., & Commandeur, H.R. 2006. Understanding new product project performance. **European Journal of Marketing**, 40 (11/12): 1178-1193.

Romijn, H., & Albaladejo, M. 2002. Determinants of innovation capability in small electronics and software firms in southeast England. **Research Policy**, 31 (7): 1053-1067.

Rothwell, R. 1974. The "Hungarian Sappho": some comments and comparisons. **Research Policy**, 3 (1): 30-38.

Rothwell, R., Freeman, C., Horlsey, A., Jervis, P., Robertson, A.B., & Townsend, J. 1974. SAPPHO updated – Project SAPPHO phase II. **Research Policy**, 3 (3): 258-291.

Rubenstein, A.H., Chakrabarti, A.K., O'Keefe, R.D., Souder, W.E., & Young, H.C. 1976. Factors influencing innovation success at the project level. **Research Management**, May: 15-20.

Salomo, S., Gemünden, H.G., & Billing, F. 2003a. Dynamisches Schnittstellenmanagement radikaler Innovationsvorhaben, in: Herstatt, C. and Verworn, B. (eds.) **Management der frühen Innovationsphasen – Grundlagen, Methoden, neue Ansätze:** 161-194. Wiesbaden: Gabler.

Salomo, S., Steinhoff, F., & Trommsdorff, V. 2003b. Customer orientation in innovation projects and new product development success – the moderating effects of product innovativeness. **International Journal of Technology Management**, 26: 442-463.

Salomo, S., Weise, J., & Gemünden, H.G. 2004. **Planning and process management of product innovations: The moderating effect of innovativeness.** 11th International Product Development Management Conference, Dublin, Ireland. School of Business Studies, The University of Dublin – Trinity College: 1115-1130.

Schlaak, T.M. 1999. **Der Innovationsgrad als Schlüsselvariable – Perspektiven für das Management von Produktentwicklungen**. Wiesbaden: Deutscher Universitätsverlag.

Schmalen, H., & Wiedemann, C. 1999. Erfolgsdeterminanten von Neuprodukten deutscher Hochtechnologieunternehmen. **Zeitschrift für Betriebswirtschaft (ZfB)**, 69 (1): 69-89.

Song, X.M., & Parry, M.E. 1997. A cross-national comparative study of new product development processes: Japan and the United States. **Journal of Marketing**, 61 (2): 1-18.

Sudman, S. 1999. Sampling in the Twenty-First Century. Journal **of the Academy of Marketing Science**, 27 (2): 269-277.

Szakasits, G.G. 1974. The adoption of the SAPPHO method in the Hungarian electronics industry. **Research Policy**, 3 (1): 18-28.

Thamhain, H.J. 1990. Managing technologically innovative team efforts toward new product success. **Journal of Product Innovation Management**, 7 (1): 5-18.

Urban, G.L., & Hauser, J.R. 1993. **Design and Marketing of New Products**. Upper Saddle River, NJ: Prentice Hall.

Vakkuri, J., & Meklin, P. 2006. Ambiguity in Performance Measurement: A Theoretical Approach to Organisational Uses of Performance Measurement. **Financial Accountability & Management**, 22 (3): 235-250.

Van der Panne, G., Van Beers, C., & Kleinknecht, A. 2003. Success and failure of innovation: A literature review. **International Journal of Innovation Management**, 7(3): 309-338.

Verworn, B., Lüthje, C., & Herstatt, C. 2000. **Innovationsmanagement in kleinen und mittleren Unternehmen.** Arbeitspapier Nr. 7, Technische Universität Hamburg-Harburg.

Voss, C.A. 1985. Determinants of success in the development of application software. **Journal of Product Innovation Management**, 2 (2): 122-129.

Yap, C.M., & Souder, W.E. 1994. Factors influencing new product success and failure in small entrepreneurial high-technology electronic firms. **Journal of Product Innovation Management**, 11 (5): 418-432.

ZEW 2007. **Innovationsverhalten der deutschen Wirtschaft. Indikatorenbericht zur Innovationserhebung 2006.** Mannheim.

Appendix

Independent variables	Scale
NPD Process	
Stage-specific effort	
Idea screening:	5…clearly organized
The screening of ideas is…	1…not organized/not always performed
Concept testing:	5…clearly organized
The testing of concepts is…	1…not organized/not always performed
Profitability check:	5…clearly organized
The use of profitability checks is…	1…not organized/not always performed
Innovation strategy:	5…clearly organized
The development of the innovation strategy is…	1…not organized/not always performed
Prototyping phase:	5…clearly organized
The prototyping phase is…	1…not organized/not always performed
Ex-post performance analysis:	5…clearly organized
The use of performance analysis is…	1…not organized/not always performed
Acceptance testing:	5…clearly organized
Acceptance testing is…	1…not organized/not always performed
Monitoring	
Market development and technology development are systematically tracked by a monitoring department	1= yes 0 = no
Involvement of marketing dept.	
What share of their total working hours do employees in the marketing department spend dealing with innovation projects (as a percentage)?	% of total working hours
Organization	
Cooperation activities	
With whom do you cooperate in the development of new products and services?	
Competitors	5…intensive cooperation 1…no cooperation so far
Customers	5…intensive cooperation 1…no cooperation so far
Suppliers	5…intensive cooperation 1…no cooperation so far
Universities and research institutions	5…intensive cooperation 1…no cooperation so far
Project management & - controlling	
Systematic project management	5...intensive use
We use systematic project management for innovation activities.	1…not used so far
Project controlling	5…intensively
We constantly control the development of the innovation project.	1…not applied so far
Innovative Culture	
Formalized incentive system	
Is there a formalized incentive system for the creative performance of your employees?	1…yes 0…no
Training activities	
How many days per year do your employees use for training and education?	No. of days per employee p.a.
Promotors	
Promotors are appointed for innovation projects to guide the project throughout its duration.	5…always 1…never
Senior Management	
Commitment	
Clear innovation goals given	5…always
Senior management defines clear goals for innovation management.	1…never
Controlling innovation process	5…always
Senior management controls the development of innovation projects.	1…never
Strategy	
Innovation expenditures (% of sales)	% of sales

Dependent variables		
Percentage of turnover generated by innovations introduced on the market within the past three years	-	% of sales
Percentage of profits generated by innovations introduced on the market within the past three years	-	% of sales
Number of innovations introduced on the market within the past three years	-	Number of innovations
Process innovation	-	% of cost reduction
Number of patents granted within the past three years	-	Number of patents
Amount of expenditures for innovation	-	% of sales
Control variables		
Size (employees)	-	Number of employees*
Industry (manuf. sector dummy)	-	1=Products 2=Services

* For the regression models, we used the logarithmized values of size in order to avoid biases due to the distribution of the data.

The complete questionnaire (in German) can be obtained from the authors.