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Causes and Effects of a Single Informant Bias in Empirical Innovation Research

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ABSTRACT

Empirical organizational research has serious methodological limitations if it is based on the perceptions of single informants. Single informant studies are likely to suffer from a systematic measurement error, a so-called method error or informant bias which negatively impacts the validity of their empirical findings. Previous empirical innovation research is based on single informants. This causes substantial doubts regarding the validity of findings in past empirical innovation research based on perceptual, self-reported measures and their managerial implications. This study undertakes a comprehensive theoretical and empirical investigation into the causes and the effects of a single informant bias in empirical innovation research. Based on multiple informant data on various aspects of innovation management in a company, multitrait-multimethod analyses are applied in order to quantify the extent of the informant bias. The results show that the informant bias is substantial and that construct validity cannot be achieved based on the assessments of a single informant only. Only multiple informant data allows the selection of an appropriate informant depending on the organizational trait to be measured based on formal statistical criteria. The higher the level of interfunctional integration and the higher the intensity of vertical communication inside the organization, the lower is the informant bias. This information can be used by researchers to assess whether an informant bias is likely to occur prior to conducting empirical surveys. The findings of this study substantiate the presumed doubts about the validity of past single informant studies in innovation research and demand the use of multiple informants in future empirical studies.

KEY WORDS

Informant Bias, Innovation, Multiple Informants, Perception, Validity.

INTRODUCTION

Empirical studies in organizational research often face the problem that, because of the nature of the questions under investigation and the lack of well-documented archival data, they have to rely on respondent-based surveys to test hypotheses (Kumar, Stern and Anderson 1993). Respondents are referred to as 'informants' because they are not required to provide personal attitudes, opinions, or means of behavior (Campbell 1955). Informants are asked to provide generalizable statements "about patterns of behavior, after summarizing either observed (actual) or expected (prescribed) organizational relations" (Seidler 1974, p. 817). It is known that measurement errors are likely to occur through the surveying of informants (Bagozzi, Yi and Phillips 1991; Campbell and Fiske 1959, March and Simon 1958). Measurement errors are mainly caused by differing motives, limited capacities to process information, perceptual differences, and differing levels of knowledge of informants (Golden 1992; Huber and Power 1985; Nisbett and Ross 1980; Schwenk 1985). Although questioned on identical aspects, significant differences among the data collected from different informants have been observed frequently: "... there may be little correspondence between informant reports and actual events" (Kumar, Stern and Anderson 1993, p. 1634).

Measurement errors caused by surveying informants in empirical organizational research can have a negative impact on construct validity. Construct validity is defined broadly "as the extent to which an operationalization measures the concept it is supposed to measure" (Bagozzi and Yi 1991, p. 427). Construct validity is the fundamental requirement in empirical research, because hypotheses should be tested only after construct validity has been achieved for all measures required for testing the hypotheses (Bagozzi, Yi and Phillips 1991). The construct validity of measurements can only be verified if at least two methods of measurement for the same organizational trait are used: "A fundamental principle in science is that any particular construct or trait should be measurable by at least two, and preferably more, different methods. Otherwise the researcher has no way of knowing whether the trait is anything but an

artifact of the measurement procedure" (Churchill 1979, p. 70). Consequently, empirical studies based on single informants are problematic because they do not allow researchers to explicitly test for construct validity. This methodological aspect is an essential part of science: "...a hypothesis might be rejected or accepted because of excessive error in measurement, not necessarily because of the inadequacy or adequacy of theory" (Bagozzi, Yi and Phillips 1991, p. 422).

Innovation is one of the most important determinants of company performance (Capon, Farley and Hoenig 1990; Han, Kim and Srivastava 1998). Because of its immediate managerial relevance, empirical innovation research, especially into the antecedents of innovation performance, has received great attention among researchers over the years. This popularity is made evident by the many publications of review articles and meta-analyses on the findings of previous empirical studies on success factors of innovations (Balachandra and Friar 1997; Brown and Eisenhardt 1995; Ernst 2002; Gerwin and Barrowman 2002, Henard and Szymanski 2001; Krishnan and Ulrich 2001; Montoya-Weiss and Calantone 1994).

Some authors have pointed to severe methodological shortcomings of previous empirical innovation research, especially the use of single informants, which can have a negative effect on the validity of empirical findings and the implications for managing innovation (Brown and Eisenhardt 1995; Wind and Mahajan 1997). Because of the inherent complexity of managing innovation in firms, as expressed for example by the involvement of multiple departments in the innovation process, it can be assumed that the restriction to single informants in empirical innovation research is insufficient and will eventually cause a significant measurement error. In general, the informant bias affects those empirical studies in innovation research that are based on perceptual, self-reported measures. Other forms of empirical studies based on 'objective' measures, e.g. patent data, are not impacted by this type if bias and are not in the focus of this work. This methodological aspect is not only of scientific, but also of managerial relevance. Recommendations to management with respect to success factors of

innovations, as for example by means of benchmarking (Cooper and Kleinschmidt 1995), could be made with more confidence on the basis of valid measurements (Wind and Mahajan 1997). This avoids the danger that management is mislead to implement a set of appealing drivers of innovation performance which are the result of measurement error.

To sum up it can be said that the single informant approach in previous empirical innovation research based on perceptual measures causes substantial doubts regarding the validity of its findings and its managerial implications. This fundamental observation leads to the following three main areas of concern: First, the extent of measurement error caused by informants and its impact on the validity of findings in empirical innovation research has not been analyzed to date. The answer to this fundamental question would allow researchers and managers to assess the validity of previous empirical studies and to draw conclusions regarding the required methodological design of future empirical studies. The impact of informant effects on construct validity can only be tested if a multiple informant approach is used in empirical innovation research. Second, in case of multiple informant data, researchers need to know how they should select the appropriate informant depending on the organizational trait they want to investigate. Third, researchers would ideally like to know prior to conducting empirical research, if informant effects are likely to occur.

The empirical findings of this study will eventually make three contributions regarding these three areas of concern. First, conclusions regarding the suitability of single informant studies in past and future empirical innovation research can be made. For this purpose, multiple informant data was gathered for this study that enable the application of multitrait-multimethod (MTMM) analysis (Bagozzi, Yi and Phillips 1991; Campbell and Fiske 1959). MTMM analysis quantifies the extent of the measurement error caused by different informants and allows a formal assessment of its impact on construct validity. Second, the results from the MTMM analysis provide clear information on how to select the appropriate informant for a specific organizational trait. Third, the findings lead to the identification of funda-

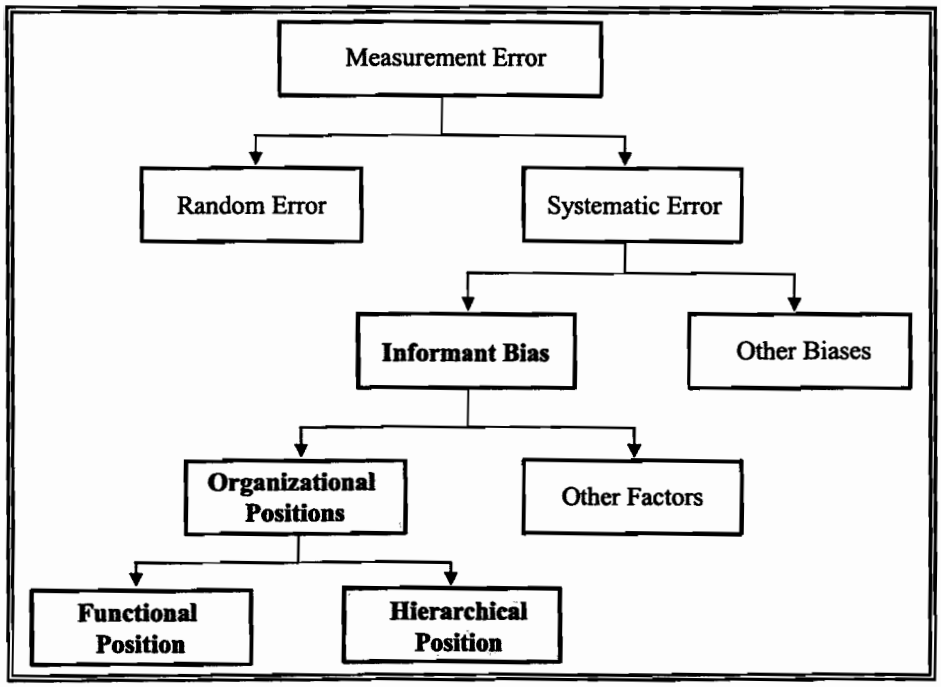
mental causes of the extent of the informant bias, e.g. the intensity of inter-functional integration as a predictor of an informant bias between respondents from varying functional backgrounds. This information can be used as an efficient and effective diagnostic tool to assess the likelihood and extent of informant effects prior to conducting empirical innovation research.

THEORY AND HYPOTHESES

Types of Measurement Error

Figure 1 systematizes the basic types of measurement error in empirical research. Total measurement error can be divided into random and systematic error (Churchill 1979). Random error is defined as the random deviation of an observed measure from its theoretically 'true' value. Random error influences the reliability of measurements (Bagozzi 1984). Reliability is an important, but not a sufficient requirement for establishing the validity of measurements (Churchill 1979). In contrast to random error, the systematic measurement error influences the validity of a measurement. The systematic error is also called method error because it is attributed to the method used for measurement. The method error causes a systematic deviation of an observed measure from the theoretically 'true' value (Churchill 1979). If the method error is too high, construct validity cannot be achieved, which makes the testing of hypotheses based on these measures impossible (Bagozzi 1984; Campbell and Fiske 1959). A formal statistical test for construct validity can only be applied if at least two methods are used to measure the same construct (Bagozzi 1984).

Figure 1: Measurement Errors in Empirical Research



A particular form of method error is the informant bias, whereby various informants represent a specific method of measurement (Bagozzi, Yi and Phillips 1991). The informant bias results from the informant's position held within the organization under investigation: "But knowledgeable informants may disagree because they hold different organizational positions and thus different perspectives on the same organizational phenomena. In other words, informant bias taints their reports" (Kumar, Stern and Anderson 1993, p. 1636). Two basic organizational positions, which informants hold in their firm, are their functional affiliation as well as their hierarchical position. Since innovation processes are cross-functional and require the interaction between managers from various hierarchical levels (Griffin and Hauser 1996), it can be argued that an informant bias is especially relevant in empirical innovation research. The main causes of an informant bias in innovation research are explored with regard to the hierarchical and the functional position of informants in the next paragraphs.

Functional Position and Informant Bias

Interpretative schemes cause differences in perceptions among informants from various functional areas. In the case of innovations, these schemes manifest themselves in so-called departmental 'thought worlds' which develop a common system of meaning regarding the management of innovation (Dougherty 1992). Informants from these 'thought worlds' draw on their known and trusted sources of information, so that the evaluation of innovation is carried out from their biased perspective. Individual informants are not able to make generalizable and cohesive statements about the management of innovation in their organization. Each 'thought world' develops its own perceptions about innovation that differ from those of other 'thought worlds' (Dougherty 1992): "Departmental thought worlds partition the information and insights. Each also has a distinct system of meaning, which colors its interpretation of the same information, selectively filters technology-market issues, and produces a qualitatively different understanding of product innovation. ...It is more like the tales of eye witnesses at an accident, or of individuals in a troubled relationship - each tells a complete story, but tells a different one" (Dougherty 1992, p. 191).

Innovation requires the integration of specialized knowledge from various functional areas (Griffin and Hauser 1996). In particular, the collaboration between marketing, research and development (R&D) and production has been identified as a success factor of innovations (Kahn 1996). These functional areas, especially marketing and R&D are not always well integrated in new product development (Song and Parry 1992). This can be attributed to various factors, such as different personality types, cultures, languages or organizational barriers for collaboration (Griffin and Hauser 1996; Lawrence and Lorsch 1967). A lack of functional integration can cause an informant bias between informants from different functional areas.

Empirical studies on the integration between marketing and R&D show that R&D managers are dissatisfied with the transfer of marketing information, for example about customer requirements and market research results, into the R&D lab (Lapierre and Hénault 1996).

Marketing managers are dissatisfied with the reciprocal transfer of technological information, for example about R&D's capabilities or technological trends (Lapierre and Hénault 1996). This dissatisfaction with the inter-functional information transfer can lead to a biased assessment by informants from R&D (marketing) regarding the marketing-related (R&D-related) responsibilities in new product development.

Further, R&D and marketing managers are often dissatisfied with the level of integration in the early phases of new product development. The achieved degree of integration between R&D and marketing was found to be particularly insufficient during 'new product concept generation' and 'screening of new products' (Song and Parry 1992). An informant bias is therefore expected to occur when informants from marketing or R&D are asked to assess those variables that are related to the early phases of the innovation process. Consequently, the level on inter-functional integration between R&D and marketing should have an impact on the extent of the informant bias.

To sum up it can be said that perceptions regarding the assessment of the management of innovations can differ between informants with different functional backgrounds in their organizations. A few empirical studies have already shown the existence of these perceptual differences between informants from different functional positions (Dearborn and Simon 1958; Dougherty 1992; Woiceshyn 1997). These studies, however, lack an explicit quantification of the extent of the informant bias, which allows an assessment of the informant bias' impact on the validity of measurements. The informant bias should especially occur in situations where the informant is surveyed about those aspects of innovation management that are directly related to the interface between the informants' respective functional areas. The extent of the informant bias should then depend on the level of integration of the respective functional areas. The following hypotheses will therefore be tested:

Hypothesis 1: The functional position of informants leads to an informant bias.

Hypothesis 2: The extent of the informant bias caused by the functional position of informants varies depending on the specific organizational trait to be assessed by the informants.

Hypothesis 3: The higher the level of inter-functional integration, the lower is the informant bias caused by informants from the respective functional areas.

Hierarchical Position and Informant Bias

Perceptional differences among informants from differing hierarchical levels can be attributed to diverging interpretative schemes (Bartunek 1984; Daft and Weick 1984). These schemes reflect attitudes, theories and predispositions that have been developed over time and are based on informants' personal experiences. Schemes help informants select and/or categorize complex information in order to simplify situations in which decisions are to be made. Informants from particular hierarchical positions display similar schemes, which differentiate them from other informants from other hierarchical positions. Studies show, for example, that the age differences between managers across various hierarchical levels are greater than within one hierarchical level (Ireland et al. 1987). Persons from one age group will display similar life experiences, values and/or attitudes that manifest themselves in comparable schemes. Further, employees from one hierarchical level tend to have similar amounts of experience in a company or in other organizations, as opposed to employees from differing hierarchical levels (Ireland et al. 1987). Finally, management tasks vary across the hierarchical levels, so that those experiences, which were carried out in the recent past, will differ. Recent events have a strong influence on the evaluation of current situations (Ireland et al. 1987). These observations show that interpretative schemes differ between employees from various hierarchical levels. As a result, perceptions can differ among informants from various hierarchical levels, which causes an informant bias.

Biased responses are also caused by the fact that informants, due to cognitive restrictions, use heuristic methods in order to simplify decision-making processes (Nisbett and Ross

1980; Tversky and Kahnemann 1974). Of particular relevance in this context is the so-called 'availability heuristic' whereby informants base their assessments on available information (Nisbett and Ross 1980). Differing amounts of available information between hierarchical levels can lead to an informant bias. As an example, hierarchically lower positioned employees have restricted knowledge about the strategies employed by the organization, while higher management has less information about operational, project-related activities carried out at lower hierarchical levels. It has been further shown that the occurrence of 'salient events', which strongly influence perception, differs between hierarchical levels (Keisler and Sproul 1982; Nisbett and Ross 1980): "What is salient at one level may be totally irrelevant at another because of the different tasks performed. For example, at the technical level, events or information, such as morale of production employees, loss of an account because of quality control problems and a complaint of an unfair dismissal, are likely to be salient. In contrast, examples of salient events or information at the institutional level might include: a sudden drop in stock price, a loss of market share, a change in the bonus plan, and a change in government antitrust policy" (Ireland et al. 1987, p. 472).

Informants tend to attribute certain events or outcomes to causes, which are in their own favor. This effect is called 'attributional bias' (Kahneman, Slovic and Tversky 1982). This can lead to an assessment that particular decisions or actions are more rational or systematic than they actually were. This type of bias occurs particularly frequently in the informants' own domain of responsibilities where informants are likely to attribute success to their own activities and failure to activities outside their immediate area of control (Nisbett and Ross 1980). In the case of innovations, for example, informants from higher hierarchical levels may attribute the failure of a project to factors where the responsibility for execution lies primarily at the operational level, whereas informants from lower hierarchical levels may attribute the failure of the same project to a lack of senior management support.

It can be summarized that the hierarchical position of respondents can lead to an informant bias in empirical innovation research. Some empirical works have identified perceptual differences between informants from various hierarchical levels in other fields of organizational research (Hambrick 1981; Ireland et al. 1987; Salancik and Meindl 1984). The informant bias is believed to vary according to the specific aspects of innovation management under investigation. It is further postulated that the extent of an informant bias caused by varying hierarchical positions is influenced by the level of vertical communication within an organization. The assessment of, for example, a firm's innovation strategy by respondents from varying hierarchical positions can be impacted by the way the innovation strategy has been communicated within the organization. Accordingly, the following hypotheses will be tested:

Hypothesis 4: The hierarchical position of informants leads to an informant bias.

Hypothesis 5: The extent of the informant bias caused by the hierarchical position of informants varies depending on the specific organizational trait to be assessed by the informants.

Hypothesis 6: The higher the intensity of vertical communication between hierarchical levels, the lower is the informant bias caused by the hierarchical position of informants.

METHOD

Sample and Data Collection

Collecting multiple informant data requires a sophisticated data collection procedure; thus, a traditional questionnaire was not sent to companies. The data collection was embedded in a small consulting project where each participating firm obtained a comprehensive benchmarking analysis identifying strengths and weaknesses of its innovation management and providing recommendations for improving the performance of innovations. Each company nominated an employee to supervise the coordination of the survey within the organization. Critical terms and expressions used in the questionnaire were defined prior to the survey in the specific context of the firm. All respondents had the opportunity to ask the contact person in

his company or to call the researchers directly whenever questions arose while filling out the questionnaire. The results of the benchmarking analysis were presented in each of the participating firms while the board of directors was present. Each presentation and the subsequent discussion ranged from three hours to the entire day. This gave us the opportunity to gain further insight and to better interpret some of the empirical results. The strong commitment of each participating organization ensured a complete data set with no missing values. It should be noted that a self-selection bias is likely to be present in the data set.

43 companies, primarily from the machinery, chemical and electronics industry participated in the study. Companies were surveyed on various characteristics of their innovation management. In each company, six knowledgeable and experienced respondents with their company's innovation management from different organizational positions were surveyed. Three respondents are from the senior management level and three respondents come from project teams. Project teams are usually responsible in the sample firms to manage innovations at the operational level. For each of the two hierarchical levels, respondents always stem from R&D, marketing and production. These three functional departments are typically most involved in the innovation process and are, therefore, relevant for this investigation (Kahn 1996). Senior management in this study includes those managers heading the three respective functional departments in their respective firms. Senior managers reported to the board of directors, which is referred to as top management in this study. Complete data for 43 firms lead to a total number of 258 observations as the basis for the analyses. Regarding the respondents, 129 are from senior management and project teams, respectively, and 86 respondents are from R&D, marketing and production, respectively.

Measures

Innovation management: Empirical studies into success factors of innovations have been very popular in the past. Meta analyses and review articles have summarized previous

findings and identified some core antecedents of innovation performance (Ernst 2002; Gerwin and Barrowman 2002; Henard and Szymanski 2001; Montoya-Weiss and Calantone 1994). These core success factors will be used for this empirical analysis and they include the following constructs: 'proficiency of the innovation process', 'proficiency of pre-development', 'process monitoring', 'customer integration', 'strong project champion', 'climate for innovation', 'top management support', 'top management accountability' and 'innovation strategy'. All variables were measured as multi-item constructs. The final items used to measure each method-independent construct after the scale optimization step in the MTMM analysis, including the respective α-values, are listed in the appendix. In this regard, the present study has the common structure known from previous empirical research on antecedents of innovation performance (Brown and Eisenhardt 1995).

Inter-functional integration: The focus of the analysis will be on the integration between R&D and marketing because these two functional areas collaborate extensively in the entire innovation process from idea to market launch (Kahn 1996). Thus, the level of inter-functional integration between R&D and marketing should have an effect on the aspects of innovation management included in this analysis. Inter-functional integration between R&D and Marketing was measured as a multi-item construct according to the scale used by Kahn (1996). Confirmatory factor analyses for each group of informants from R&D and marketing show that the constructs measuring inter-functional integration are independent of the respective measurement method. The α-value is .89 for informants from R&D and .83 for informants from marketing.

Vertical communication: Vertical communication was measured as a multi-item construct based on the scale developed by Jaworski and Kohli (1993). Confirmatory factor analyses for each group of respondents from senior management and the project level show that the measurements for the construct 'vertical communication' are independent of the measurement method. The α-value is .70 for informants from the senior management level and .77 for in-

formants from the project level.

Analyzing Multiple Informant Data

The gathered multiple informant data from the sample firms will be analyzed by means of MTMM analysis. The MTMM approach was developed in the field of psychology to test for construct validity (Campbell and Fiske 1959). 'Trait' refers to the construct being measured and 'method' to the means used to measure the 'traits'. The MTMM analysis decomposes total variance into three types of variance: (1) 'trait variance', (2) 'method variance' and (3) 'random error' (Bagozzi and Yi 1991). Multiple informants represent varying measurements methods in this study. 'Method variance' will therefore indicate the extent of the informant bias in the following MTMM analyses.

The data were analyzed following the technical procedures suggested in the literature for performing a MTMM analysis (Bagozzi, Yi and Phillips 1991). A detailed discussion of the MTMM procedure would go beyond the scope of this paper. A comprehensive description of the MTMM analysis with numerous practical applications can be inferred from the literature (Bagozzi, Yi and Phillips 1991; Kim and Lee 1997). In an MTMM analysis, two steps of evaluation need to be carried out subsequently. First, the initial scale purification process tests whether common constructs (traits) can be established independent of the measurement methods, i.e. informants from the two hierarchical levels (senior management and project team) and informants with different functional backgrounds (R&D, marketing and production). Confirmatory factor analyses for each group of respondents were performed for this purpose. For respondents from different functional areas, seven out of the nine initial constructs of innovation management are independent of the measurement method. For respondents from different hierarchical levels, eight out of the nine initial constructs of innovation management are independent of the measurement method. The respective items and α-values for the method-independent constructs are listed in the appendix.

Second, a subsequent test of construct validity was performed for the method-independent constructs (Bagozzi, Yi and Phillips 1991). Due to the large number of constructs and the recommendation in the literature to conduct MTMM analyses with a maximum number of three to four traits (Conway 1998), the constructs were split into two groups for the MTMM analyses. In total, four MTMM analyses were performed with Lisrel 8.53 as confirmatory factor analyses. A maximum-likelihood estimation, recommended for small samples (Anderson and Gerbing 1988), was carried out in each MTMM analysis. The overall goodness of fit for all four confirmatory factor analyses, as indicated by Comparative Fit Indices greater than the required value of .90 (Bagozzi, Yi and Phillips 1991; Kim and Lee 1997), is very good. The respective $\chi 2$-tests reveal that the 'trait-method model' in all four analyses yields significantly better results in comparison to the 'null', 'trait only' and 'method only' models (Bagozzi, Yi and Phillips 1991; Kim and Lee 1997). The sufficient indicators of model fit for all four MTMM analyses allow the following interpretation of the results.

RESULTS

Extent of the Informant Bias

Tables 1 and 2 summarize the key output from the MTMM analyses, i.e. the decomposition of total variance into trait and method variance. The remaining variance can be attributed to random error. Trait and method variance are derived from squared factor loadings obtained from the respective MTMM analyses. Trait variance should account for at least 50% of the total variance for establishing construct validity (Bagozzi, Yi and Phillips 1991).

It becomes evident that the functional position of the informants leads to highly biased assessments and makes the valid measurement of the constructs impossible. The informant bias is on average larger than the trait variance. Construct validity is furthermore not achieved

for individual constructs because of insufficient levels of trait variance and high method variances. The extent of the informant bias varies between constructs. The informant bias of respondents from R&D and marketing is particularly large where the interface between the two functions is directly affected ('proficiency of pre-development' and 'customer integration'). These findings confirm hypotheses one and two.

Table 1: Decomposition of Variance: Extent of Trait Variance and Method Variance (Informant Bias) for Informants from Different *Functional* Areas

Informant from...	...R&D		...Marketing		...Production	
Construct	Trait	Method	Trait	Method	Trait	Method
Proficiency of Innovation Process	.55[a] (30%)[b]	.22 (5%)	.59 (34%)	.41 (17%)	.55 (30%)	.52 (27%)
Proficiency of Pre-Development	.50 (25%)	.87 (75%)	.48 (23%)	.60 (36%)	.56 (31%)	.44 (19%)
Process Monitoring	.54 (29%)	.28 (8%)	.47 (22%)	.55 (30%)	.50 (25%)	.55 (30%)
Customer Integration	.40 (16%)	.44 (20%)	.52 (27%)	.69 (47%)	.51 (26%)	ns
Climate for Innovation	.32 (10%)	ns	.64 (41%)	.29 (8%)	.45 (20%)	.54 (30%)
Top Management Support	.64 (41%)	.77 (59%)	.59 (35%)	.81 (66%)	.42 (17%)	.65 (42%)
Top Management Accountability	.61 (37%)	ns	.61 (37%)	.20 (4%)	.51 (26%)	.47 (22%)
Total (Mean Variance):	**23%**	**28%**	**30%**	**29%**	**26%**	**29%**

a = Significant factor loadings ($p < .05$); b = Variance (squared factor loading); ns = not significant (small variances); Mean trait (method) variance over all informants = 28% (30%); Random error can be inferred by subtracting the %-values of trait and method variance from 100%.

In sum, a sufficient degree of construct validity cannot be achieved based on the assessments of respondents from a specific functional background. Thus, the conclusion can be made that past empirical studies based on informants from one functional area are potentially affected by an informant bias and that the results have to be carefully re-assessed because the validity of their measurements is questionable.

The hierarchical position of informants also leads to an informant bias, which accounts on average for 33% (senior management) and 28% (project level) of total variance (table 2). This finding confirms hypothesis four. The informant bias varies substantially between the constructs (hypothesis five). In contrast to the earlier results for informants with different functional backgrounds (table 1) some constructs can be measured with a sufficient degree of validity based on the assessments of respondents from either the senior management or the project level. Respondents from the project level provide valid assessments for the constructs 'proficiency of pre-development', 'process monitoring', 'customer integration' and 'strong project champion'. Respondents from senior management appear to be inappropriate respondents for assessing some core elements related to the innovation process. The high error variance for the constructs 'customer integration' and 'strong project champion' reveals that informants from senior management lack the knowledge to assess these aspects of innovation management. Random error is mainly caused by an insufficient degree of knowledge of respondents regarding the organizational trait under investigation (Kumar, Stern and Anderson 1993). This indicates that senior management is not fully involved with these operational activities. Further, the strong informant bias for the constructs 'proficiency of pre-development' and 'process monitoring' occurs where senior management has the primary responsibility for making project selection and termination decisions.

Table 2: Decomposition of Variance: Extent of Trait Variance and Method Variance (Informant Bias) for Informants from Different *Hierarchical* Positions

Informant from...	...Senior Management		...Project Level	
Construct	Trait	Method	Trait	Method
Proficiency of Innovation Process	.70[a] (50%)[b]	.37 (14%)	.52 (27%)	.86 (73%)
Proficiency of Pre-Development	.40 (16%)	.46 (21%)	.71 (50%)	.25 (6%)
Process Monitoring	.27 (8%)	.60 (36%)	.80 (63%)	.55 (30%)
Customer Integration	.40 (16%)	ns	.83 (69%)	ns
Strong Project Champion	.52 (27%)	ns	.74 (55%)	.23 (5%)
Top Management Support	.77 (59%)	ns	.40 (16%)	.63 (40%)
Top Management Accountability	.95 (90%)	ns	.36 (13%)	.41 (17%)
Innovation Strategy	.61 (37%)	.79 (62%)	.40 (16%)	.48 (23%)
Total (Mean Variance):	**38%**	**33%**	**39%**	**28%**

a = Significant factor loadings ($p < .05$); b = Variance (squared factor loading); ns = not significant (small variances); Mean trait (method) variance over all informants = 38% (30%); Random error can be inferred by subtracting the %-values of trait and method variance from 100%.

Senior management does provide valid assessments of the constructs 'proficiency of innovation process', 'top management support' and 'top management accountability'. For these constructs, respondents from senior management are less biased than informants from the project level (table 2). The informant bias of project level managers for the construct 'top management support' may result from the fact that innovation projects often have to fight for

scarce resources. Informants from the project level may therefore feel that the resources spent on innovations are insufficient.

Neither project level managers nor senior managers are able to provide valid assessments for the construct 'innovation strategy'. The informant bias for senior managers may be attributed to their involvement in formulating and implementing an innovation strategy. The innovation strategy does not seem to be clearly communicated to the respondents from the project level. Thus, it is conceivable that the intensity of communication between hierarchical levels in the organization impacts assessments and hence the extent of the informant bias. This cause of an informant bias will be examined in more detail in the next paragraph.

Factors Impacting the Extent of the Informant Bias

Hypothesis three postulates that the extent of the informant bias is impacted by the level of integration between the respective functional areas in the firm. To determine the extent of the informant bias, the Euclidean distance between pairs of answers from the respective informants from the two functional areas was determined for the respective constructs (Foxman, Tasuhaj and Exstrom 1989). As two informants come from each functional area, a total number of four pair-wise comparisons were done in order to determine the variance of assessments per construct between respondents from R&D and marketing.

A correlation analysis between the level of inter-functional integration and the extent of the informant bias was performed. Only significant results are reported in table 3. The analysis differentiates according to how the level of inter-functional integration is viewed either by informants from R&D or from marketing. As there is no strong agreement as suggested by a low correlation coefficient ($r = .30$), a separate analysis of both functional areas' perspectives is required. Compliant with the initial hypotheses, one should expect negative correlation coefficients for the constructs. This is the case for all constructs (table 3).

Table 3: Level of *Inter-Functional Integration* and the Extent of the Informant Bias

		Level of Inter-Functional Integration	
		R&D's Perspective	Marketing's Perspective
Extent of Informant Bias regarding...	...Proficiency of Innovation Process	-.18 (ns)	-.49***
	...Proficiency of Pre-Development	-.63***	-.45***
	...Customer Integration	-.80***	-.50***

N = 43; Various types of correlation analyses (Pearson, Kendall-Tau) lead to identical results; Levels of significance: *** $p < .01$; ** $p < .05$; ns = not significant; correlation coefficient between R&D's and marketing's perception of the level of inter-functional integration: $r = .30$.

Independent of the respective perspective, the level of inter-functional integration correlates negatively with the extent of the informant bias for the constructs 'proficiency of pre-development' and 'customer integration'. The worse the informants from both functional areas judge the level of integration between their respective functional areas, the higher are the perceptual differences for the assessment of the 'proficiency of pre-development' activities and 'customer integration' into the innovation process. A very strong informant bias had been found in the previous MTMM analyses for these two constructs (table 1). As postulated in hypothesis three, a strong informant bias occurs at the interface between R&D and marketing during the innovation process, if the level of inter-functional integration is low.

A significant negative correlation for at least one of the two functional areas can be observed for the construct 'proficiency of innovation process'. The worse the informants from marketing judge the level of inter-functional integration with R&D, the larger are the perceptual differences regarding the construct 'proficiency of innovation process'. Discussions with the respondents from the sample firms revealed that respondents from marketing often felt that the innovation process was largely controlled and managed by R&D in their firms and that marketing lacked substantial influence. This explains why respondents from marketing

systematically disagree with respondents from R&D on the assessment of construct one 'proficiency of the innovation process', especially when the level of inter-functional integration is rated low by respondents from marketing. This result shows that the perception of one functional area of the level of inter-functional integration alone can lead to an informant bias.

A strong informant bias for respondents from R&D and marketing has further been observed for the construct 'top management support' (table 1). The variance of assessments between respondents from R&D and marketing is significantly ($p < 0.05$) lower compared to the mean variance of all constructs. Informants from R&D and marketing are in agreement for this construct. This leads to an informant bias independent of the level of inter-functional integration. With regard to aspects that fall mainly into the area of responsibility of others, i.e. top management, in the organization, a significant amount of agreement can be observed. This observation points towards the existence of an informant bias caused by the hierarchical position of respondents.

Hypothesis six presumes that the extent of the informant bias between respondents from different hierarchical levels is influenced by the degree of vertical communication inside the firm. The extent of the informant bias was again measured by the Euclidian distance between pairs of answers from the respective informants from both hierarchical levels. Since three informants come from each hierarchical level, a total number of nine pair-wise comparisons were made to determine the variance of assessments per construct between respondents from the two hierarchical positions.

A correlation analyses between the intensity of vertical communication and the extent of the informant bias was performed. Only the significant results are shown in table 4. The analyses are again differentiated according to the perception of vertical communication by respondents from both hierarchical levels due to a low level of agreement on the intensity of vertical communication between informants ($r = .31$). As expected in the initial hypothesis, negative correlation coefficients for all constructs can be observed.

Table 4: Intensity of *Vertical Communication* and the Extent of the Informant Bias

		Intensity of Vertical Communication	
		Senior Managers' Perspective	Project Level Managers' Perspective
Extent of Informant Bias regarding...	...Proficiency of Innovation Process	-.17 (ns)	-.53***
	...Proficiency of Pre-Development	-.36***	-.16 (ns)
	...Process Monitoring	-.27**	-.29**
	...Top Management Support	-.08 (ns)	-.37***
	...Innovation Strategy	-.68***	-.22*

N = 43; Various types of correlation analyses (Pearson, Kendall-Tau) lead to identical results; Levels of significance: *** $p < .01$; ** $p < .05$; * $p < .10$; ns = not significant; correlation coefficient between senior managers' and project level managers' perception of the intensity of vertical communication: $r = .31$.

Independent of the perspective, the level of vertical communication correlates negatively with the extent of the informant bias for the constructs 'process monitoring' and 'innovation strategy', i.e. the worse the informants from either hierarchical level evaluate the level of vertical communication, the larger are the perceptual differences with regard to the assessment of these two constructs. This confirms findings from the MTMM analyses that revealed a high informant bias regarding the assessment of these two constructs (table 2). Discussions with informants from the sample firms revealed that project level managers frequently argued that project monitoring was not transparent and decisions not well-communicated in the organization. Informants from senior management argued that the innovation strategy was not sufficiently communicated by top management within the organization. Obviously, the level of vertical communication has a strong impact on the extent of the informant bias among respondents from different hierarchical levels. These findings confirm hypothesis six.

Further, significantly negative correlations are observed depending on the respective perspective of the respondents for the constructs 'proficiency of innovation process', 'proficiency of pre-development' and 'top management support'. These results show that the perception of respondents from one hierarchical level about the intensity of vertical communication in the organization can already lead to an informant bias caused by these respondents. This result confirms the earlier findings of the MTMM analyses (table 2) and further supports hypothesis six.

DISCUSSION

The findings of this study clearly show that the hierarchical as well as the functional position of informants lead to an informant bias in empirical innovation research. The extent of the informant bias seriously impacts the validity of measures for organizational traits. The informant bias accounts for, on average, almost 30% of total variance. Two constructs, 'climate for innovation' and 'innovation strategy', could not be measured with a sufficient degree of construct validity based on any of the informants surveyed in this study. These results support the initial hypotheses one and four.

The informant bias caused by the respondents' functional position varies according to the respective organizational trait to be assessed by the informants. This result confirms hypotheses two. On average, the informant bias is higher than the variance explained by the constructs (traits). Low trait variance and the high extent of the informant bias led to insufficient levels of construct validity which would have made it impossible to test hypotheses on potential success factors of innovations based on informants either from R&D, marketing or production only. The conclusion can therefore be made that past empirical studies based on informants from one functional area are severely affected by an informant bias and that the results have to be carefully re-assessed because the validity of measurements is highly questionable.

The informant bias caused by the hierarchical position of respondents is also high. At the level of the individual construct, however, informants from either one of the two hierarchical levels make valid assessments with a high degree of trait variance and a low informant bias. Hypotheses with regard to potential success factors of innovations could have been tested for seven out of nine constructs either based on the assessment of informants from senior management or from the project level. The varying degrees of the informant bias, depending on the respective organizational trait under investigation, require the inclusion of multiple informants in NPD research. These findings support the initial hypothesis five.

The level of inter-functional integration impacts the extent of the informant bias. Low levels of integration between R&D and marketing lead to a high informant bias for those organizations traits where the integration of R&D and marketing is crucial in the innovation process. The constructs 'proficiency of innovation process', 'proficiency of pre-development' and 'customer integration' could not be measured with a sufficient amount of construct validity due to a strong informant bias in the assessments of respondents from these two functional areas. The intensity of vertical communication in the organization impacts the extent of the informant bias of respondents from different hierarchical levels. A low intensity of vertical communication leads to a high informant bias especially for the constructs 'proficiency of innovation process', 'proficiency of pre-development', 'process monitoring', 'top management support' and 'innovation strategy'. The findings further show that the perception of respondents from one functional area of the level of inter-functional integration and the perception of respondents from one hierarchical level of the intensity of vertical communication alone can lead to an informant bias caused by the respective group of respondents. These findings support the initial hypotheses three and six.

On may argue that the observed informant bias could be at least partly caused by varying degrees of knowledge between the respondents. Respondents were asked to make a self-assessment of their competence for each organizational trait in the survey. This type of spe-

cific competence evaluation is superior to global indicators of competence, such as the respondent's position in the firm or his or her number of years employed with the firm (Kumar, Stern and Anderson 1993). All respondents in this survey were carefully selected based on their competence to assess innovation management in their respective firms. This is illustrated by a high mean value, 4.4 on a five-point scale, for the self-assessment of competence by the respondents. Respondents from senior management rate their competence significantly ($p < .05$) higher compared to respondents from the project level; probably caused by the fact that senior managers are more self-confident about themselves or that they want to appear most knowledgeable. The findings of the MTMM analyses have shown a high informant bias also for respondents from senior management. This result implies that competence does not prevent the occurrence of an informant bias. The informant bias is caused by systematic perceptual differences of competent respondents, rather than by varying degrees of knowledge between respondents.

This study has limitations that could lead to further research. The empirical analysis is based on a relatively small sample of firms due to the chosen data collection procedure. The thorough collection of complete multiple informant data in close cooperation with firms is considered to be superior for this type of research over a less thorough approach aiming to maximize the sample size (Brown and Eisenhardt 1995). To obtain further evidence though, future studies with larger samples are desirable. This study examines two organizational positions of informants that can lead to an informant bias. Future studies might explore the impact of other organizational positions of respondents on the informant bias. Further, other factors, for example corporate culture, that potentially impact the extent of the observed informant bias could be tested empirically. Also, the number of variables chosen in this study to characterize innovation management in firms is incomplete. Therefore, further aspects of managing innovation should be explored utilizing the same methodological approach used in this study. Finally, a construct such as 'customer integration' was measured from the firm's own per-

spective as it is usually the case in empirical innovation research. Measuring this construct also from the customer's perspective would probably allow a better validation of this important aspect of innovation management.

CONCLUSION

The main objective of this study was to assess the impact of an informant bias on the validity of empirical innovation research. The empirical results clearly confirm the core hypotheses of this study and show that empirical innovation research based on perceptual, self-reported measures is seriously affected by an informant bias. Therefore, results from many previous empirical innovation studies, which are based on single informants, need to be interpreted with great caution. Their results are likely to be biased and the scientific and managerial implications should not be generalized. Based on the findings of this study, new methodological approaches in future empirical innovation research of this type are required.

In general, more emphasis should be placed in publications on providing relevant biographical information about informants. A review of past empirical innovation research shows that authors hardly report detailed information about their informants. When the sample is described, at least the distribution of informants in terms of their organizational positions in their respective firms should be provided. This would make a first assessment of the impact of a potential informant bias in empirical studies that are based on single informants possible.

Using single informants in empirical innovation research is inappropriate if informant effects are to be expected. Informants should generally be knowledgeable regarding the subject under investigation. This reduces random error, however, it does not lower the informant bias. The findings suggest that researchers should suspect an informant bias especially in those instances when the potential informant is mainly responsible for the subject under investigation or when potential informants usually interact regarding the organizational trait which should be measured, for example, when informants from marketing and R&D are asked to

assess 'customer integration' or the 'proficiency of pre-development'. The level of inter-functional integration and the intensity of vertical communication can be used as an efficient diagnostic tool prior to the main survey. If an informant bias has to be anticipated, at least a dyad of informants per organization needs to be surveyed. Only multiple informant studies enable the application of MTMM analyses in order to formally test for construct validity and to identify the best informant for each organizational trait under investigation. The main advantage of this approach is that the selection of the best informant can be based on objective statistical criteria. In cases, in which the informant bias is too high to achieve construct validity, other forms of empirical research, for example document analyses or case studies, should be pursued.

Establishing valid measurement scales is a fundamental prerequisite for testing hypotheses in empirical research. Hypotheses ought to be tested only, if construct validity of all measures is given. This has not been the case in previous empirical innovation research. This fundamental shortcoming severely impedes the theoretical and managerial implications from this type of innovation research. Future empirical studies should avoid this methodological pitfall and must further contribute to setting higher methodological standards for empirical innovation research.

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APPENDIX

1. *Proficiency of Innovation Process* ($\alpha_{SM} = .80$; $\alpha_{PT} = .75$; $\alpha_{RD} = .84$; $\alpha_{MA} = .69$; $\alpha_{PD} = .80$)

   - (H, F) We usually manage our projects according to a defined process
   - (H, F) The activities and responsibilities for each phase of the innovation process are clearly defined
   - (H, F) The proficiency of activities is usually high in all phases of the innovation process

2. *Proficiency of Pre-Development* ($\alpha_{SM} = .69$; $\alpha_{PT} = .73$; $\alpha_{RD} = .71$; $\alpha_{MA} = .72$; $\alpha_{PD} = .68$)

   - (H, F) The proficiency of feasibility studies conducted prior to the development phase is usually high
   - (H, F) The relative product advantage for the customer is usually clearly defined prior to the development phase
   - (H, F) We are usually doing an excellent job selecting and prioritizing innovation projects before entering the development phase

3. *Process Monitoring* ($\alpha_{SM} = .74$; $\alpha_{PT} = .73$; $\alpha_{RD} = .67$; $\alpha_{MA} = .69$; $\alpha_{PD} = .77$)

   - (H, F) Innovation projects are usually systematically assessed at defined milestones
   - (H, F) The innovation process is usually continuously monitored over all phases during the innovation process

4. *Customer Integration* ($\alpha_{SM} = .83$; $\alpha_{PT} = .70$; $\alpha_{RD} = .73$; $\alpha_{MA} = .75$; $\alpha_{PD} = .78$)

   - (H, F) Customers are usually integrated into the innovation process at an early stage, i.e. prior to the development phase
   - (H, F) During the innovation process there is usually an intensive communication with customers
   - (H) Innovation teams are usually explicitly required to seek customer input during the project
   - (H, F) Customers frequently make contributions to our innovation projects

5. *Strong Project Champion* ($\alpha_{SM} = .79$; $\alpha_{PT} = .79$)

   - (H) There is usually a dedicated and strong project champion in each innovation project
   - (H) The project champion is usually clearly visible in the organization
   - (H) The project champion is usually involved in all phases of the innovation process and not only in specific phases

6. *Climate for Innovation* ($\alpha_{RD} = .69$; $\alpha_{MA} = .74$; $\alpha_{PD} = .72$)

   - (F) The climate in our organization is favorable for the development of innovations
   - (F) There is enough room in our organization for inventors to exploit their creativity
   - (F) The organization rewards intrapreneurs who take risks pushing forward new ideas

7. *Top Management Support* ($\alpha_{SM} = .75$; $\alpha_{PT} = .72$; $\alpha_{RD} = .73$; $\alpha_{MA} = .73$; $\alpha_{PD} = .81$)

   - (H, F) Top Management is committed to innovations
   - (H, F) The R&D budget is adequate to achieve the objectives with our innovation projects
   - (H, F) The total innovations budget (incl. expenses for market research and product launch) is adequate to achieve the objectives with our innovations projects
   - (H, F) Human resources are adequate to achieve the objectives with our innovations

8. *Top Management Accountability* ($\alpha_{SM} = .71$; $\alpha_{PT} = .67$; $\alpha_{RD} = .82$; $\alpha_{MA} = .67$; $\alpha_{PD} = .67$)

- (H, F) The performance of innovations is regularly and systematically monitored
- (H, F) Rewards or compensations of top management are based on the accomplishment of defined performance targets for innovations

9. *Innovation Strategy* ($\alpha_{SM} = .70$; $\alpha_{PT} = .75$)

- (H) The objectives for innovation projects are clearly defined
- (H) The objectives for innovation projects are clearly communicated inside the organization
- (H) Our portfolio of innovation projects follows a strategic course giving direction to the sum of single innovation projects

Respondents:

SM = Senior Management; PT = Project Team Members; RD = Research & Development; MA = Marketing; PD = Production.

Methods in MTMM analyses: H = Hierarchical Position of Informant; F = Functional Position of Informant.

Further notes:

Constructs 5 and 9 are not method-independent for informants from different functional backgrounds and construct 6 is not method-independent for informants from different hierarchical levels.
α = Cronbach's Alpha. Only those items are shown which remain after completing the scale optimization process. All items were measured on a five-point scale (strongly disagree (1) – strongly agree (5)).

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