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Working Paper

Functional chains of knowledge management: effects on firms' innovative performance

Jena Economic Research Papers, No. 2007,080

Provided in Cooperation with:

Max Planck Institute of Economics

Suggested Citation: Cantner, Uwe; Joel, Kristin (2007) : Functional chains of knowledge management: effects on firms' innovative performance, Jena Economic Research Papers, No. 2007,080, Friedrich Schiller University Jena and Max Planck Institute of Economics, Jena

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JENA ECONOMIC RESEARCH PAPERS



2007 – 080

Functional Chains of Knowledge Management – Effects on Firms' Innovative Performance

by

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www.jenecon.de

ISSN 1864-7057

The JENA ECONOMIC RESEARCH PAPERS is a joint publication of the Friedrich-Schiller-University and the Max Planck Institute of Economics, Jena, Germany. For editorial correspondence please contact m.pasche@wiwi.uni-jena.de.

Impressum:

Friedrich-Schiller-University Jena
Carl-Zeiß-Str. 3
D-07743 Jena
www.uni-jena.de

Max-Planck-Institute of Economics
Kahlaische Str. 10
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Functional Chains of Knowledge Management – Effects on Firms’ Innovative Performance

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ABSTRACT. The aim of this paper is to investigate the role of Knowledge Management (KM) for the innovation success of firms. It is assumed that the functional chains of KM lead directly and indirectly to more innovative success via enhancing the recombination of internal and external knowledge assets. To analyse the embedding of KM in a firm’s internal system of innovation we establish a structural equation model. We capture KM as latent concept and trace different functional chains by which KM impacts. Using data on KM and innovation success of 351 German firms of the manufacturing sector and knowledge-intensive services located in Thuringia and Hesse, our findings confirm the (dynamic) capability function of KM, which leads via improving exploitation of internal and external innovation assets to more innovation success.

KEYWORDS: Knowledge management, innovation, absorptive capacity, resource-based view, structural equation modelling

JEL: O32, D21, C3

1. Introduction

The notion Knowledge Management (KM) comprises activities of a firm to organize its knowledge assets. Besides different definitions of KM, its confirmed intention is to increase a firm's economic and innovative performance. Empirical research so far captures KM rather in a narrow way concentrating on IT-based and technical issues of KM. Our aim is to capture all the facets of present KM including tacit and incentive-based dimensions of KM. Furthermore, there exists a lack of empirical evidence on the complex causalities between a firm's management of knowledge and its innovation success. Often, the impact of KM is treated as a black box. This may, of course, arise from a general difficulty to measure management success. In addition, through causal ambiguity a firm's success cannot directly be subscribed to one management measure (Davenport *et al.*, 1998; Lippman *et al.*, 1984). In analysing the impact on innovation success, we want to investigate the (dynamic) capability function of KM increasing the successful use of innovation assets in a firm.

Most research concentrates on unidirectional causalities between measures of (knowledge or innovation) effort and innovation performance. There exist, however, multi-way causalities between the firm's innovation assets, its ability to combine and apply them, and its commercialisation success (Kogut *et al.*, 1992; Mata *et al.*, 1995; Swan *et al.*, 1999). We take those interdependencies of management strategies and related success indicators into account by applying structural equation modelling (SEM) (Arbuckle, 2005; Jöreskog *et al.*, 1970; Kline, 1998, amongst others). Applying SEM, we generate multisided causalities between KM, a firm's innovation activities and its innovation success.

The paper proceeds as follows. Section 2 serves as the theoretical foundation of our model. It is divided into two parts. In section 2.1 we discuss aspects of knowledge, which we acknowledge as relevant to be addressed by KM and which provide the basis for our KM measurement

concept. In section 2.2 we theoretically derive the three channels, by which KM is supposed to influence innovative success. After describing our data in section 3, followed by explanation of SEM in section 4, we present our structural equation model (section 5) and investigate on which action paths KM contributes to a firms' innovative performance. A model assessment in section 6 is followed by discussion of outcomes and concluding remarks in section 7.

2. Theoretical background

Innovation is built on collective knowledge sharing activities of, especially, tacit knowledge (Howells, 1996; Nonaka *et al.*, 1995; Gibbons, 1994). Dialogue and frequent interaction between different individuals or groups forms the basis for knowledge recombination and creation of innovation. Due to this interaction, relationships and perspectives are shared between employees creating a cooperative atmosphere useful for the transfer of tacit knowledge (Gold *et al.*, 2001). At this point KM gains importance: it is seen as a managerial tool which can promote the knowledge creating and sharing processes essential for innovation. Theoretical approaches as well as implementation strategies of KM concentrate a lot on IT related issues (Swan *et al.*, 1999; Nonaka *et al.*, 2000, 6, Alavi *et al.*, 2001). However, knowledge sharing activities cannot be enhanced by IT networks alone. KM is rather an organizational device, a problem-solving tool, which increases knowledge exploration and knowledge exploitation success of firms (Swan *et al.*, 1999, 264). Hence, there is a need for a shift towards organizational and personnel issues in KM (Carter *et al.*, 2001).

2.1 Aspects of knowledge and respective Knowledge Management

2.1.1 Tacit knowledge and KM

Tacit knowledge was made prominent by Polanyi (1962) and gains increased importance in innovation economics literature (Cowan et al., 2000; Howells, 1996; Johannessen *et al.*, 2001; Rüdiger *et al.*, 1998). Most important is the difficulty or impossibility to express, verbalize or communicate it. Tacit knowledge is hard to gain, often only by experience, learning-by-doing or observation. It is specific to person or context, and it may be uncertain or even considered unimportant to anyone else (Swan *et al.*, 1999). Tacit knowledge is influenced by subjective categories, intuition and hunch. It is deeply embedded in procedures and routines, as well as in values and beliefs. This is why it has to be extracted, or crystallised (Nonaka *et al.*, 2000), to become explicit. For Spender (1996) tacit knowledge is knowledge which is not yet abstracted from practice. Since tacit knowledge is essential to innovation (Grant, 1996; Hall, 1993; Nonaka *et al.*, 1995), it is also in focus of Knowledge Management. Especially, a firm's routinized and uncodified working processes often contain tacit knowledge. In a way, tacit knowledge becomes a habit, which no-one in a firm can explain. "This is the way things are done around here" is often mentioned in this context (Spender, 1996). This obviously is a challenge for KM measures (Dick *et al.*, 2002). The tacitness of knowledge is addressed if for example creativity techniques like brainstorming and mind mapping are institutionalized, or if meetings and work groups take place to exchange ideas. Communities of practice, mentioned by Probst *et al.* (1999), can also contribute to sharing of tacit knowledge across departments.

2.1.2 Explicit knowledge and KM

Explicit knowledge is the codified part of knowledge, captured in data, words, numbers or symbols (Polanyi, 1958, Johannessen *et al.*, 2001; Cowan *et al.*, 2000). Its management is often realized in the application of IT-tools. In most firms, IT-supported KM systems are the initiation of

deliberately storing and organizing its knowledge resources. Access to information is speed up and operational efficiency is created (Johannessen *et al.*, 2001). IT-infrastructure has the advantage, that it reduces the risk of “knowledge walking out of the door” (Swan *et al.*, 1999). On the other hand explicit knowledge can pass more easily the firm borders. There is a trade-off between making knowledge explicit and leaving it in the heads of workers. The aim of IT-based KM in this respect is mainly to prevent it running out of a firm’s capabilities and core competences. The danger is that when IT communication infrastructure is simply installed, social interaction between a firm’s knowledge sharing entities are left to chance and individual inclination. IT-oriented KM can come to grips with such problems, if it goes along with an advanced human resource management and organizational practices which support the building of social networks (Swan *et al.*, 1999). Dick *et al.* (2002, 11) emphasize, that not the technical realization of KM is the problem but the organizational embedding of KM systems. They emphasize the importance of knowledge workers participating in the process of change caused by the implementing KM (Dick *et al.*, 2002). Often, skilled workers contribute only that part of their knowledge, that is codifiable at all and that they are willing to contribute. If a worker has no incentive to make his knowledge available to the firm, the firm cannot use this knowledge as vital part of its knowledge base. This problem just leads to our third issue.

2.1.3 Incentive-based KM

Besides the concentration of KM on the dimensions of knowledge, we view incentive structures as an essential feature of KM. The willingness to share and diffuse knowledge, to participate in knowledge creation and deployment processes in the firm depends considerably on the incentives employees have and therefore on their professional competence (Mandl *et al.*, 2000). Knowledge workers are the major carriers of knowledge ensuring the competitive advantage of firms (Probst *et al.*, 1999). They are the main object of KM (Grant, 1996). The installation of organisational and technical KM provides infrastructural KM in a firm.

By this it offers opportunities to share, to create and to use knowledge. Nevertheless, it is the knowledge worker who finally maintains these knowledge processes. And he in turn, is perhaps not willing or not able to contribute all his knowledge to the firm. Alternatively he follows a “not-invented-here” strategy, which means that he does not accept knowledge from outside and runs the risk of lock-in in routines and habits (Probst *et al.*, 1999). Incentive-based KM is targeted on the motivation of employees to use new knowledge, to question given solutions from time to time, to be willing to share knowledge. We view incentive measures like a bonus system and knowledge culture creating tools like decentralization of decision power and increased responsibility of employees as important part of KM.

The KM facets just discussed are in our view necessarily to be taken into account by our model. These detailed aspects can be left out in the following part, where we derive our hypotheses on the specific functional chains of KM in general.

2.2 Innovation success and absorptive capacity

2.2.1 Knowledge Management and Innovation

Our general presumption is that KM increases knowledge work performance and by this the innovative success of firms. This consideration is based on the resource-based view (RBV) of the firm (Barney, 1991; Wernerfelt, 1984, Rumelt, 1984). The RBV views idiosyncratic resources as main source of competitive advantage. Since firms are not equally able to generate valuable and embedded resources out of their assets, they perform heterogeneously. In his definition, Barney (1991) emphasizes organizational processes as a resource and particularly discusses information processing systems as factor of competitive advantage. Following this, we view KM as resource which directly increases the success of firm’s innovative activities and by this causes heterogeneity amongst firms. This presumption is made explicit

for the innovation success of firm i being dependent on her innovation resources, her innovation cooperations and her knowledge management:

$$[1] \text{InnoSuccess}_i = f(\text{InnoResources}_i, \text{InnoCooperation}_i, \text{KnowledgeManagement}_i)$$

Recent empirical work treating KM as resource in the sense of the RBV sustains the direct impact of KM on firms' innovation success. This positive impact is shown by Liao *et al.* (2006) who suppose that KM makes firms more receptive to innovation opportunities. Huergo (2006), by using a production function model, hints to the positive influence of technology management on the generation of both product and process innovation in Spanish manufacturing firms. In a qualitative study Gold *et al.* (2001) find evidence for the organizational effectiveness of different KM tools. Due to an OECD initiative several countries conducted surveys on KM, amongst them Germany (Edler, 2003), France (Kremp *et al.*, 2003) and Canada (Earl *et al.*, 2003). They find similar positive impact of KM on innovation propensity. Based on this literature our first hypothesis reads as follows:

H1: KM directly improves the innovation success of firms.

2.2.2 Knowledge Management and internal innovation assets

If we want to know, which impact KM has on the firm, how it enhances innovation in detail, there is a need to look closer on the firm assets involved in the knowledge recombination process and especially addressed by KM. We suppose to discover KM impact in the successful exploitation of a firm's innovation resources. Hence, we expect KM to act as "meta-resource" behind a firms' resources. We define meta-resources as idiosyncratic organizational resources of a firm, which yield the inherent potential to increase the effectiveness of use of existing resources in a firm. This view can be related to the discussion of dynamic capabilities of firms (Eisenhardt *et al.*, 2002), defined by Teece *et al.* (1997) as "*the firm's ability to integrate, build, and reconfigure internal*

and external competences to address rapidly changing environments.” By calling the capabilities dynamic Teece *et al.* refer to the ability to renew competences in order to adapt to changing business developments. These facilities are labelled capabilities because “*the term emphasizes the key role of strategic management in appropriately adapting, integrating, and reconfiguring internal and external organizational skills, resources, and functional competences to match the requirements of a changing environment.*” (Teece *et al.*, 1997, 515)

The pure accumulation of technology assets alone does not make the market successor, since there may still be a lack of useful capabilities. The key is to implement a management that coordinates and deploys internal and external competencies effectively (Teece *et al.*, 1997). Ray *et al.* (2004) claim that resources per se can only be source of competitive advantage if they are applied, if “something is done with them”. The resources have to be exploited through business processes in order to be used more efficiently. This, however, is to be seen only as possibility, because not all assets can become valuable scarce resources by exploitation (Ray *et al.*, 2004; Porter, 1991). Hence, KM can be seen as firm process improving capability or as meta-resource. Drawing on the notion of KM as part of a meta-structure behind all valuable, rare and hard-to-imitate resources, we assume that KM affects the assets deployed in the innovation process itself. We assume KM to leverage the internal innovation assets of firms

$$[2] \text{ InnoSuccess}_i = f(\text{InnoResources}_i \cdot \text{KnowledgeManagement}_i, \text{InnoCooperation}_i)$$

Our respective hypothesis 2 reads as follows:

H2: KM improves the exploitation of existing internal resources leading to an increased innovation success.

2.2.3 KM, absorptive capacity, and external innovation assets

Since Cohen *et al.* (1990) the firms' capacity to value external information, to assimilate and commercialize it, is labelled absorptive capacity. In order to achieve an effective integration of external knowledge there is a need for an advanced system of knowledge processing. The conception of such a system, called absorptive organizational capacity (Cohen *et al.*, 1990), has gained increased attention and has inspired studies on knowledge management (see for example Coombs *et al.*, 1998; Caloghirou *et al.*, 2004; Lenox *et al.* 2004; Yang, 2005). Different studies following Cohen *et al.* (1990) consider those organizational aspects of absorptive capacity. Kogut *et al.* (1992) propose that the existing knowledge stock cannot be regarded separately from its level of organisation, or the firm's combination capabilities. Van den Bosch *et al.* (1999) suggest organisational aspects as vital determinants of absorptive capacity. They consider the organizational form and the combination capability as important elements of a firms' absorptive capacity, which itself is viewed as co-evolving with the knowledge environment (Van den Bosch *et al.*, 1999).

Regarding the special case of interfirm R&D cooperation, Schmidt (2005), by using data from the "Mannheim Innovation Panel", finds evidence for the relevance of knowledge management to improve absorption of external knowledge. An elaborated human resource and knowledge management is confirmed to improve a firm's absorptive capacity, counted as realized R&D cooperations of firms. R&D cooperation contributes to a large extent to the innovative success of firms (Barringer *et al.*, 2000; Hakansson *et al.*, 1988; Powell *et al.*, 1996). To successfully exploit R&D cooperation, there is a need for organizational capabilities especially addressing the leveraging of interfirm relationships (Lorenzoni *et al.*, 1999). The ability to organize R&D cooperation, to prevent of "inventing the wheel twice" or to successfully integrate external knowledge affects also the benefit out of R&D cooperation. The enhanced exploitation of external knowledge through KM is crystallized in the following way:

$$[3] \text{InnoSuccess}_i = f(\text{InnoCooperation}_i \cdot \text{KnowledgeManagement}_i, \text{InnoResources}_i)$$

Thus, a firm undertaking R&D cooperation faces two challenges: first, to recognize the needed valuable external knowledge out of R&D cooperation and second, to successfully manage, integrate and commercialize R&D cooperation and new ideas developed. Taking into account that firms with KM capabilities can better organize such cooperation, we hereof expect a positive effect on innovation success. Thus, we derive the hypothesis for KM impact as follows:

H3: KM improves the absorptive capacity of firms leading to an increased innovation success.

2.2.4 The systemic aspect of Knowledge Management

By our hypotheses we establish a system of interaction patterns, in which KM is an embedded part and which we want to analyse. We integrate our hypotheses into a path model and solve the supposed structural equations simultaneously. In this way we build a model which as a whole represents our system of hypotheses. In this context, the assessment of the systemic character of KM is done by testing our model to deliver an appropriate explanation of the underlying data. The derived single causalities are presented in the path diagram in simplified form (see figure 1).

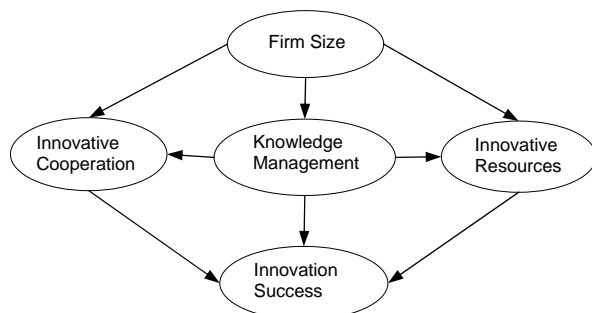


Figure 1: Functional chains of Knowledge Management

These relationships together can be formulated in a way where KM is a meta-resource as well as a direct resource contributing to a firm's innovation success:

$$[4] \text{ InnoSuccess}_i = \text{KnowledgeManagement} \cdot f(\text{InnoCooperation}_i, \text{InnoResources}_i, 1)$$

The path diagram shows the supposed relationships. Each ellipse represents a certain latent construct, based on several observed variables. Our three hypotheses introduced above are taken into account simultaneously here. Hence we formulate a hypothesis 4 suggesting a co-occurrence of all three effects of KM:

H4: KM is embedded in a firm's internal system of innovation.

3. Data

We dispose of firm data of 351 firms from the region Jena in Thuringia and from Northern Hesse. We focus on innovating firms from the manufacturing sector and knowledge-intensive services in order to concentrate on the quantifiable innovation success. We neglect the already confirmed question of whether KM in general improves the

probability to innovate and concentrate on its effect on the intensity of innovative success. In our survey we refer to firm activities of the years 2002-2005, which result in measurable innovation success in the year 2005. Table 1 gives a summarizing overview over the used variables and their descriptive characteristics.

Knowledge Management. In our survey we concentrate on eight KM tools, aggregated to three KM aspects. We distinguish three tacit KM tools, two explicit KM tools and three incentive KM tools. We asked the firms, which of the listed KM tools they apply and by which intensity (on a five-likert-scale) the tools contribute to the overall success of the firm. This information on evaluation of the eight KM tools is used for aggregation. Thus, KM is measured on a scale ranging from 1 to 15 for tacit and incentive KM aspects (*TacKM*, *IncKM*), and on a range between 0 and 10 for explicit KM (*ExpKM*). The more a firm uses the KM tools and the higher it evaluates them, the higher is the respective aggregated variable. In this way, our KM measurement model takes into account the quality with which KM is embedded in the firm. The indicator variables for the three aspects build the latent concept of **KnowledgeManagement**.

Internal and External Innovation Resources. To capture a firms' innovation input, we use the number of graduated employees, holding a university or equivalent degree (*Emp_grad*). To capture innovation expenditures, we calculate the logarithmized value of real innovation input (*LogRDexp*) to meet normal distribution requirements for the variables used in SEM. Both variables build the firm's innovation input as latent concept named **InnoResources**. To capture external innovation resources, we use the number of R&D cooperation partners, with whom cooperative projects were realized in the last three years. We add up the number of regional (*LogRegcoop*), German (*LogNatcoop*), and international R&D cooperation partners (*LogIntcoop*). We include again the logarithmized value to avoid skewness. The three variables are indicators for the latent concept of innovative cooperations a firm had, named **InnoCoop**.

Innovation Success. For the innovation output we create two innovation indices. Information is available on the type of product and

process innovation realized during the last three years. The three types of innovation are called incremental (marginal improvements), moderate (new for the firm but already existing in the market) and radical (new to the market) innovations. Incremental innovations are weighted with 1, moderate innovations are weighted with 2 and radical innovations are valued with 3. Firms marked which of these 6 innovation types they had realized. Multiple nominations were possible. Both success measures (*Prodinno*, *Procinno*), each ranging between 0 and 6, are measured values of the latent construct **Innosuccess**.

To control for size effects we included firm size. Firm size is counted in classes (*FirmsizeClass*), ranging from 1 to 6. This variable is a latent variable, named **FirmSize**, with only one indicator variable which has a loading regression weight of 1. Hence, it functions as a control variable in the model.

	N	Min	Max	Mean	Std.Dev.
<i>FirmsizeClass</i>	347	1	6	2.501	1.100
<i>Emp_grad</i>	316	0	180	8.370	16.628
<i>LogRDexpend*</i>	277	4.787	17.399	11.664	1.819
<i>LogRegcoop*</i>	218	0	3.555	0.537	0.686
<i>LogNatcoop*</i>	218	0	3.434	0.848	0.765
<i>LogIntcoop*</i>	218	0	3.045	0.323	0.609
<i>TacKM</i>	156	0	15	4.692	5.314
<i>IncKM</i>	152	0	15	5.283	5.446
<i>ExpKM</i>	246	0	10	5.756	3.149
<i>Prodinno</i>	345	0	6	2.925	1.816
<i>Procinno</i>	337	0	6	1.605	1.602

Table 1: Descriptive statistics of used variables

*We use the logarithm, to avoid skewness of distribution; and we added the number 1 to all variables to avoid non-counting of zero values.

** For missing values AMOS estimates means and intercepts and uses these estimated values for the model estimation (Arbuckle, 2006).

4. Method

In our paper we want to investigate multiple relationships between not perfectly measurable, hence latent concepts like KM and innovative success. An empirical research on such concepts, however, can only attempt to capture them with appropriate indicator variables. Here, Structural Equation Modelling (SEM) is an approach to investigate hypotheses about relationships among latent concepts, also called latent variables (for SEM see for example Hoyle, 1995; Kline, 1998; Mueller, 1996; Schumacker *et al.*, 1998). SEM is made prominently by Jöreskog and Sörbom and their LISREL (Linear Structural Relationship-) approach in 1986. The idea is to investigate relationships between latent variables, based on the covariances between the observed indicator variables building these latent variables. Structural equation models consist of measurement models of the latent constructs and of the structural model between these latent concepts (Zinnbauer *et al.*, 2005). Thus, SEM combines both confirmatory factor analysis and linear regression equations which are solved simultaneously. The overall aim of SEM is to realize multiple regression analysis.

We investigate complex and multiple relationships between latent variables under consideration instead of single directional dependencies between directly measured dependent and independent variables as in regression analysis (Emrich, 2004). For our analysis we apply the software package AMOS 6.0, which is, after LISREL and EQS one of the most applied software packages for SEM in empirical studies (Shook *et al.*, 2004).

5. Model setting

The variables described above are used to build the five latent concepts **FirmSize**, **KnowledgeManagement**, **InnoResources**, **InnoCooperation** and **InnoSuccess**, represented in figure 1. The latent variables are either endogenous or exogeneous. In our case, **FirmSize** is exogenous since it is an explanatory latent variable. The other latent concepts are

endogenous. The indicator variables (in small squares) build the latent concept. The use of latent concepts which are built of more than one indicator variable requires several technical quality fits (Zinnbauer *et al.*, 2005; Bagozzi, 1981). We used Cronbachs Alpha to verify internal consistency of our latent concepts. Cronbachs Alpha is based on the single variance of the indicator variables in relation to the variance of the latent variable. It should be above 0.7 (Garson, 2007) or for 2–3 indicators above 0.4 (Eberl *et al.*, 2005). For the relevant four latent concepts, we quantify the following Cronbach Alphas: **KnowledgeManagement** (0.51), **InnoCooperation** (0.53), **InnoSuccess** (0.54) and **InnoResources** (0.12). **InnoResources** shows a rather small Cronbach Alpha. This indicates that the commonly used measures for innovation resources, *LogRDexpend* and *Emp_grad*, do not behave in the same way. The low value is however accepted, since the indicator variables are appropriate representatives for internal innovation resources and provide a good fit for our model.

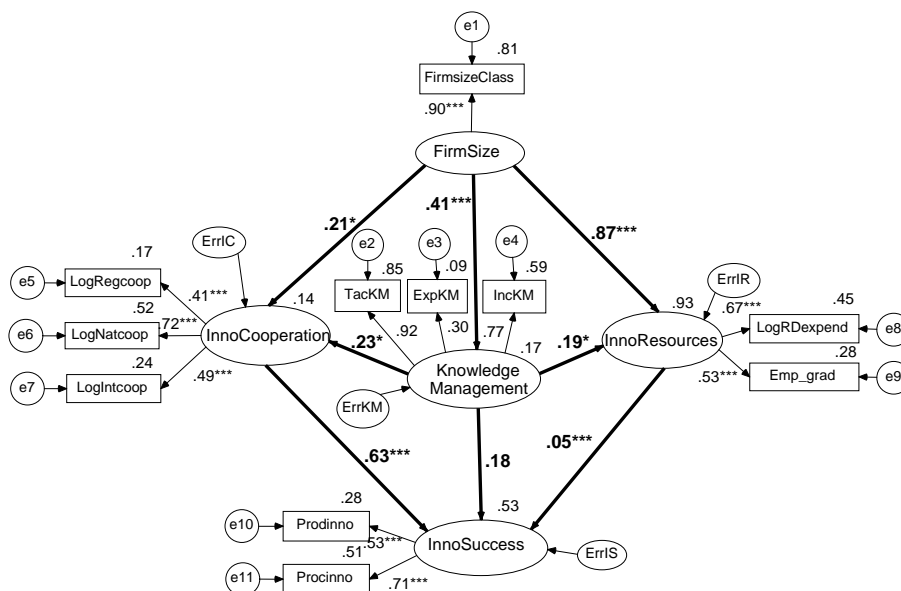
The measurement models are constructed significantly by the indicator variables. This can be seen in the regression weights close to the arrows leading from latent to the observed variables which are marked significant. For example, if **KnowledgeManagement** goes up by one unit standard deviation then *TacKM* goes up by 0.92 standard deviations. Values close to the rectangles indicate how much of the variance in the term is explained by the respective predictors of the variables, named multiple R-squared. For *FirmSizeClass* we have an explanation of variance of 0.81, indicating that 81 per cent are explained by the predictors and approximately 19 per cent of variance is explained by variance of error terms of the predictors. The error term of each indicator variable is indicated by the small circles. They represent the share of variance in the variable which is not explained by the observed variable itself.

6. Assessment of Structural Equation Model

In the following we assess our model in two steps, at first regarding the path coefficient and secondly concerning the global model fit. The path diagram in figure 1 represents the model based on the hypothesized interdependencies. With help of AMOS an implied covariance matrix is established out of the path diagram. This matrix representing the way the observed variables should covariate, is compared with the empirical covariance matrix using a Maximum-Likelihood test statistics. The chi-square test statistics opposes the null hypothesis that the implied covariance matrix corresponds to the empirical covariance matrix, with the alternative hypothesis that the empirical covariance matrix corresponds with any positive-definite matrix (Zinnbauer *et al.*, 2005), thus with the independence model. The null hypothesis holds that the implied model covariance is the best estimate of the population variances and covariances (Arbuckle, 2006). A significant chi-square model fit then implies that the observed covariance is significantly different from the observed covariance matrix of the underlying data. In that sense the chi-square test is a badness of fit-measure (Garson, 2007). Besides this, it is necessary to control also for other local and global goodness-of-fit measures, as it is done here in the following.

Structural Model and Path coefficients. Values close to the ellipses of our path diagram indicate the variance of the latent variable explained by the indicator variables. For the exogenous latent construct **FirmSize** this value is zero. The other four latent constructs are adequately high. The regression weights indicating how much of the variance in the latent concept is explained by the items should be above 0.5 (Eberl *et al.*, 2005), this holds for **InnoResources** (0.93) and **InnoSuccess** (0.53). For **KnowledgeManagement**, the explained percentage of variance out of the predictors is 0.17. **FirmSize** alone does not explain the height of KM. For **InnoCoop** we have 0.14, which is also below this threshold. Size and KM together do not predict sufficiently high the extent of cooperation. Hence there exist other influence factors for the two concepts which are omitted in the model. The error terms (ErrIC, ErrIR and ErrIS) represent a proxy for combined effects of unmeasured causes (Kline, 2005).

Direct effect. The bold structural model arrows represent the established linear equations of the functional chains under investigation and solved simultaneously. As can be seen in figure 2, some established interdependencies are significant, others not. The indicated direction is important for analyzing the direct and indirect effects and the impact on the dependent variable. The arrow directions, however, do not imply causal relationships. For our cross section data considerations of causality are not possible. Nevertheless, we are able to analyze a system of interacting and interdependent variables, thus looking at relationships in-between the firm's innovation process.



Chi-square=43.652(37 df); p=.210
 RMSEA=.023; NFI=.912; CFI=.984

Figure 2: Structural Equation Model of KM impact on innovation success; standardized direct effect estimates; p-value: < 0.01 *** ; < 0.05 ** ; < 0.1 *

The path coefficients represented here are the standardized regression weights. Of central interest is the role of KM in our model, which has a high direct effect on **InnoCooperation** (0.23) and on **InnoResources** (0.19). That means an increase of one unit standard deviation of **KnowledgeManagement** leads to an increase of **InnoCoop** by 0.23 standard deviation. However, its direct influence on **InnoSuccess** is not significant. Hence we have to reject hypothesis H1 for our model. KM does not directly improve the innovation success of firms. **InnoResources** influence the innovative success of firms in our dataset by the positive and significant coefficient of 0.05. An increase of innovative resources by the standard deviation 1 increases innovation success by 0.05.

Indirect effect. With help of SEM, we calculate direct (unmediated) and indirect (mediated) effects of latent variables (Kline, 1998; Mueller, 1996). Direct effects are displayed in the path model, indirect and total effects can be taken from AMOS output table. The standardized indirect effect is calculated by the product of the standardized direct effects (Kline, 2005). Of central interest for our research question is the indirect effect of **KnowledgeManagement** on **InnoSuccess**. This is the sum of the products of direct effects of three paths, which is $(0.23 \cdot 0.63) + (0.19 \cdot 0.05) = 0.154$ for KM.

KnowledgeManagement impacts the dependent variable indirectly via the two channels **InnoCooperation** and **InnoResources**. Therefore, we can not reject Hypotheses H2 and H3 for our model. KM enhances the exploitation of internal and external knowledge sources. We conclude that a positive indirect effect on innovative success exists, which may be an explanation why the direct effect of KM is slightly insignificant.

Global Fit. Testing for the global fit of our model and the systemic aspects of KM (as hypothesized by H4) we compute a chi-square of 43.64 at 37 degrees of freedom and a p-value of .21. Due to this insignificance we can confirm our model, since it does not significantly deviate from the behaviour of underlying data and covariance matrix. In addition other measures of global fit are verified. The RMSEA (Root Mean Square Error of Approximation) with a domain between 0 and 1 should be smaller than

0.08 to indicate a good model fit (Zinnbauer *et al.*, 2005). This requirement is satisfied in our model (RMSEA = 0.023). The NFI (Normed Fit Index) required to be above 0.9 exceeds this quality threshold (NFI = 0.912). CFI (Comparative Fit Index) and TLI (Tucker-Lewis-Index), to be higher than 0.9 and 0.95 respectively, fulfil the quality measure requirement, too. An overview of all considered global goodness-of-fit measures can be found in table 2. In sum, our hypothesized model provides a reasonable fit for the observed covariances. The variable interdependencies implied by our model can be found in the data. Hence, we cannot reject hypothesis H4 for our model and confirm the systemic pattern of KM embedded in the firm – with the exception of the direct effect of KM.

Quality Measure	Abbr.	Goodness-of-Fit Requirement	SEM
Chi-square (degrees of freedom)	χ^2 (DF)	-	43.64 (37)
P-value for model does not fit the data	P-value	> 0.1	0.21
Min. discrepancy divided by degrees of freedom*	CMIN/DF	≤ 2.0	1.18
Root Mean Square Error of Approximation	RMSEA	≤ 0.08	0.023
Normed Fit Index	NFI	≥ 0.9	0.912
Tucker-Lewis-Index**	TLI	≥ 0.95	0.972
Comparative Fit Index	CFI	≥ 0.9	0.984
Hoelter's critical N for ...	Hoelter's N		
... a significance level 0.05***	(0.05)	≥ 200	414
... a significance level 0.01***	(0.01)	≥ 200	475

Table 2: Comparison of Goodness-of-Fit-Measures, based on own calculations and on Eberl *et al.* (2005), Zinnbauer *et al.* (2005), Garson (2007)

* Minimum discrepancy between observed and (by the model) implied covariance matrix; ** Should be close to one, but is not restricted to the range of 0 and 1; *** Critical and not to exceeding sample size, up to which the model can be accepted at the respective significance level

To verify our model we investigated it also by excluding KM. This leads to a slight decrease in model fit with respect to the level of

significance, RMSEA and CFI, and a decrease in explained variance of the latent variable **InnoSuccess**. Furthermore we checked for other directions of arrows leading from innovation assets to KM. By this we wanted to test the assumption that a high amount of internal and external innovation assets leads to an increased KM activity. A test of this model leads to insignificant path coefficients and a worse model fit.

From this we conclude that KM contributes essentially to the explanation of systemic innovation. We find evidence for the detailed and multisided functional chains of KM. By this result we confirm a supporting role of KM as we measured it in the innovation and knowledge recombination process of firms. Our KM measurement model takes into account the quality and success with which KM is embedded in the firm. A shortcoming which prevents us from interpretation of causalities is the endogeneity problem since we do not use panel data. Nevertheless, our results shed some light in the black box of a firm's internal systematic process of innovation and the role KM plays therein.

7. Interpretation and Conclusion

The aim of our paper is to assess Knowledge Management as innovation enhancing capability. Instead of investigating the unidirectional and independent impact of KM we establish a linked path model in which we take into account the intermediate steps and recombinatory elements which lead to innovative success. Our aim is to provide a model which estimates the meta-resource or dynamic capability character of KM. In our model we attempt to implement theoretical considerations on organization capabilities (Cohen *et al.*, 1991; Kogut *et al.*, 1992; Teece *et al.*, 1997). Furthermore our work contributes to empirical research on Knowledge and Innovation Management and takes a micro-perspective on mechanisms of management measures.

The results of our SEM approach support the general finding of a positive impact of KM on the ability of firms to create and commercialize new ideas. With SEM we pay special attention to complex

interdependencies between variables under investigation, and to create latent constructs for those economic concepts which are a priori not perfectly measurable in empirical investigation. Our understanding of the aim of KM is that it focuses on the processing and handling of different dimensions of knowledge and initializes knowledge exchange and sharing. The model based on our hypotheses examines the interaction of KM and innovation effort as well as how this affects innovation success. Our findings figure out the complexity of KM functional chains. Our main finding is that KM tends to affect the innovative success of firms not directly but indirectly by enhancing a firm's ability to use its internal as well as external resources more effectively. Hence, KM can be considered to be a meta-resource. Obviously, we are not able to detect causalities here. This would require working with panel data – a task we have planned for the future. Other interesting questions to be tackled on the basis of such data are looking at the effect of KM on economic and innovative success, taking into account more explicitly technological fields covered, type of cooperation partners, and integration into the regional innovation system.

The authors would like to thank the Volkswagen-Stiftung for supporting the research project "RIS-Second Order Innovation", the Deutsche Forschungsgemeinschaft (DFG) and the Research Training Group DFG 1411 "The Economics of Innovative Change" for financial support of the research work related to this paper, and the DIME network for providing travelling funds. We would also like to thank participants of the DIME workshop in Athens, Nov./Dec. 2006, of the ZEW workshop in Mannheim, June 2007, and of the workshop at the IWH in Halle in July 2007 for providing opportunities to present and discuss ideas of the paper. Furthermore we would like to thank Rolf Steyer and his assistants at the Friedrich-Schiller-University Jena and Werner Bönnte of the Max-Planck-Institute for Economics in Jena for helpful comments on SEM. Special thanks to Elisa Conti for providing the idea for the innovation success indices, and to Sidonia von Ledebur and Thomas Grebel for reviewing the paper and improving its quality and style.

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