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The Use of Knowledge Management by Innovators - Empirical Evidence for Germany

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Abstract

In this paper we investigate factors that influence a firm's decision to implement knowledge management practices. Our focus is on knowledge management practices implemented to increase collaboration between actors within a firm on innovation activities. Using information on over 1,500 innovative German firms from the Mannheim Innovationpanel of 2003, we find that an innovation strategy targeted at consumers and continuous R&D activities is positively related to KM usage. In addition, more general firm characteristics like size and the industry of a firm do influence the decision to use knowledge management as well.

Keywords: knowledge management, innovation, Mannheim Innovationpanel

JEL Codes: D23, O31, O32,

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1 Introduction

The use of KM is not restricted to large companies or firms whose business is knowledge. Nowadays almost every firm in the industrialized countries is part of the so-called "knowledge economy". More concretely this means that a firm's competitive advantage is mainly based on knowledge creation, and that a firm works with knowledge assets and employs knowledge workers. Being part of the knowledge economy raises the need for strategic and operational devices to organize a firm's main production factor, knowledge, and thus to implement operational tools to manage its knowledge base. These KM tools are not only a way to organise knowledge but also enable a firm to improve its competitiveness. In this respect KM has the potential to embed and integrate knowledge assets in a way that they become a difficult-to-imitate source of a firm's competitive advantage. Consequently, an important implication is that every firm being part of the knowledge economy should show a sustained interest in practicing KM in some form. The implementation of KM, however, is costly in the sense that most of the time it involves a number of changes, like restructuring firm hierarchies, breaking up habits and routines, learning and using new information and communication technologies. Hence, firms considering such costs as too high will not pass through the effort and apply KM practices. An obvious question then upraises: which are the firms that actually practice KM and how are those firms characterised?

An increasing amount of literature emphasizes KM as firms' major challenge for the future (Hall & Andriani, 2001; Nonaka & Takeuchi, 1995; Lundvall, 2006; Yang, 2005). Furthermore, recent KM studies, concentrating on rather small samples, discuss KM predominantly in context of strategic management decisions (Alavi & Leidner, 2001; Gold et al., 2001; Yang, 2005).

We build on this literature and establish an empirical model to analyse the key characteristics, which increase the propensity of firms to apply KM. Besides size and industry we also investigate indicators capturing the internal dynamics a firm faces. Our results for a large sample of German firms confirm that especially large firms belonging to knowledge-intensive industries with a continuous and consumer-oriented innovation strategy are most likely to employ a KM strategy.

Our paper is structured as follows. At first, in section 2, we provide a literature review which concentrates on determinants of KM adopting firms. This review allows us to select major determinants which serve as constituting elements of our empirical model. In section 3 we introduce our analytical framework. Section 4 contains a description of the data and the selected variables. In section 5 we discuss our results, followed by a conclusion in section 6.

2 Literature Review

What determines a firm's propensity to implement a KM strategy? We attempt to answer this question on the basis of the Knowledge Management literature. We first review definitions of KM, before discussing promoters of KM providing incentives for a firm to organize a set of knowledge processing operations and routines. On the one hand, we see the knowledge economy as an external KM promoter, which influences every firm being part of this economy. On the other hand, certain firm characteristics may function as internal promoters facilitating a deliberate KM strategy. We start discussing the latter first.

2.1 Knowledge Management

The process of managing the existing knowledge of organizations is an ancient phenomenon and not new in the portfolio of management activities. Using employees' competences and combine them into organisational capabilities is a need wise managers have always been aware of (Lundvall, 2006).

Several definitions of KM exist in the literature. Dick and Wehner (2002) consider the function of KM in guiding different processes of knowledge transformation. The objective of a firm applying KM is simply to make the right knowledge available at the right time at the right place. Mandl and Reinmann-Rothmeier (2000) provide a broader definition of KM. For them, KM means the deliberate and systemic handling of the resource knowledge, and the object-oriented input of knowledge in organisations. They conclude that KM is an organisational method with the main aim to use the strategic resource knowledge more deliberately and more efficiently. Swan et al. (1999, 264) also stick to a rather broad definition. For them KM encompasses "… any processes and practices concerned with the creation, acquisition, capture, sharing and use of knowledge, skills and expertise …"

Besides general definitions of KM, recent literature concentrates on the formulation of concrete practices implemented to manage knowledge (Coombs & Hull, 1998; Holsapple & Singh, 2001). According to Swan et al. (1999) KM practices can be divided into the IT-based or supply driven and in the demand-driven approaches.

Supply-driven KM is maintained by IT-tools providing access to knowledge and information. It comprises hardware and software to set up and run databases, virtual teams or communication networks (Alavi & Leidner, 2001) and tools that allow organising the storage, usage and transfer of knowledge and information. In this sense KM represents the infrastructure capabilities of a firm, which enhance acquisition and distribution of rather explicit or codified knowledge (Gold et al., 2001). The importance of these infrastructural capabilities for most

firms today cannot be denied. However, two restraints have to be considered. First, infrastructure to share and distribute information and knowledge is only one aspect of successful KM, another one are the willingness, incentives, motivations of people to use it. Thus, any cultural and social facets of KM (Alavi & Leidner, 2001) are not taken into account by supply-driven approaches. Second, considering KM's ability to integrate knowledge and information in a way that a firm specific resource is generated – a unique knowledge and competence base - , IT infrastructure alone cannot provide for this. All firms can buy and implement IT infrastructure; as a result it is no more a source of competitive advantage (Johannessen, 2001).

The demand driven approach of KM is concerned with the human and managerial elements of KM (Davenport, 1995; Nonaka & Takeuchi, 1995; Swan et al., 1999). The focus here lies more on the cultural and social dimension of the creation, sharing and application of knowledge. The aim of KM practices is to crystallize, exchange and apply knowledge, often located in people's heads, for innovation. Especially tacit knowledge, often highly relevant for innovation, is being approached here. It is personal and context-specific, requires shared meaning, and knowledge exchange possibilities (Swan et al., 1999). Knowledge bases and competences built up in this sense contribute to a firm's competitiveness and are thus considered as a resource. IT infrastructure obviously may serve as a supportive tool but it cannot substitute demand driven practices.

Despite a wide range of KM definitions and practices it becomes clear that a KM strategy concentrating on innovation should encompass especially the demand-driven and knowledge sharing approaches of KM. Due to this, we will focus more on knowledge creation and sharing activities of a firm to identify firms with KM in our dataset.

2.2 The knowledge economy: external promoter of KM application

Looking at the determinants that lead firms to implement KM we first refer to external promoters. Here we consider at the knowledge economy on the one hand and the learning economy on the other. Both consider knowledge and knowledge creation as pivotal for firms to be competitive. Grant (2002) establishes major features of the knowledge economy: First, knowledge is the central resource in the knowledge economy just as land is in the agrarian and capital in the industrial economy. Second, intangible assets, services, technology or brands are more decisive for a firm's success than financial or tangible assets. Furthermore, the world is a network, sustained by advanced communication technologies, which enables knowledge to cross boarders and distances without deceleration. Information is increasingly digital and virtual. All those features constitute the 'new knowledge economy' which is subject to rapid change (Grant, 2002). Lundvall (2006) concentrates more on the learning economy. This concept refers

to the phenomenon, that knowledge becomes obsolete more rapidly. Thus, it is necessary for firms to forget old and obtain new knowledge and competencies more quickly. In a sense, the learning economy concept refers more to the capabilities a firm needs, whereas the knowledge economy perspective focuses more on the respective resource "knowledge". Both are distinguished aspects of a knowledge society.

For firms, which are part of the knowledge society, knowledge as the major production factor is a challenge to face and to draw strategic conclusion out of. The managerial requirements here are different from those in bygone eras. Whereas in former times the access to physical assets was the key to competitive advantage, in the knowledge society it is the access to knowledge, to competences and to creativity. Firms create needs to meet them and problems to be solved by them (Nonaka et al., 2000). They do not only process information but they do also work with knowledge, i.e. they create knowledge by action and interaction. Firms create, own, protect and use difficult-to-imitate commercial and industrial knowledge assets. They realize that knowledge is their source of sustainable competitive advantage and highest quality power in order to succeed in mastering rapid change (Teece, 2000).

Both, the knowledge and the learning economy require organizational capabilities to anticipate and manage the dynamics of change (Eisenhardt & Martin, 2000; Gold et al., 2001, Teece et al., 1997). Knowledge has to be managed, capabilities have to be learned. In this sense the implementation of knowledge management techniques and tools can be seen as a reaction to phenomena of the knowledge and learning economy.

2.3 Firm characteristics: internal promoter of KM application

The previous section's aim has been to show that a general need for KM derives out of the phenomena and growing importance of the knowledge economy. Complementary to this external pressure for KM, we show by citing the relevant literature that a need for KM can arise out of a firm's inherent characteristics, which are the focus of our empirical analysis below.[1]

Our argument is based on the resource-based view of the firm (Barney, 1991; Wernerfelt, 1984; Rumelt, 1984). There, firms are considered heterogeneous in their resources, their structure and their focus towards the use of knowledge (Barney, 1991). In general they differ in their knowledge-intensity of production and thus in their dependence of knowledge and their need to implement KM. In the following we identify various factors related to the knowledge requirements

[1] We did not deduce any formal hypothesis to be tested empirically from the first part of our literature review, since it is quite hard to measure the general exposure to the knowledge economy of a certain firm with more general variables. Indicators on firms' innovation behaviour discussed below will help us to assess the importance of knowledge for a firm to a certain degree, however.

of firms. Based on these findings, we suggest hypotheses about the determinants of KM implementation by firms.

2.3.1 Characteristics of Innovation Activities and Firms' Knowledge Bases[2]

Continuity of innovative activity

Innovative activities are one way for firms to achieve competitive advantage (Grant, 1996; Nonaka & Takeuchi, 1995; Utterback & Abernathy, 1975). In order to achieve a sustainable competitive advantage a firm has to design a strategy for continuous innovative success. For this to work a firm has to consider the following two aspects of innovative activities: First, innovation often is a path-dependent result of continuous and repeated reconfiguration of knowledge. This implies that further innovative success heavily draws from a firm's accumulated knowledge base. Second, continuous innovation requires receptiveness towards changes in the market, in technology, competition or products. Consequently, successful companies take change in an uncertain world as an everyday event and show the willingness to partly retain and to partly abandon what has long been successful (Nonaka & Takeuchi, 1995). Hence, compared to isolated successful one-shot innovations, sustained innovation activity requires efforts to continuously organise the knowledge base of the firm, in the sense of developing knowledge and abandoning less useful knowledge (Coombs & Hull, 1997; Webster, 2004; Grant, 1996).

Empirical evidence on this relationship is presented in Hargadorn (1998) and Liao & Chuang (2006). They both argue that firms adopting KM continuously develop new products or new processes. As Hargadorn (1998) shows this applies even more to so-called "knowledge brokers". Knowledge brokers are firms seen as the modern invention factories, specialised on continuously producing innovative solutions for novel problems. They mainly link innovative ideas of one industry to new problems occurring in another industry (Hargadon, 1998; Mandl et al., 2000). The major task knowledge brokers are facing is to learn, link and apply knowledge in order to sustain a continuous flow of innovative ideas. Their need of organizational support for exchanging ideas and gate-keeping activities becomes most obvious.

As a first hypothesis (HYP 1) we suppose, that firms following a continuous innovation strategy are more likely to adopt KM practices, than those with occasional innovation activities.

Consumer-orientation of Innovative activity

[2] A vast amount of literature has discussed KM and its relevance for innovation activities. We will only review the literature that focuses on consumer-orientation of innovationn activities and continuous R&D activities below. The interested reader can turn to e.g. Coombs & Hull (1998); Davenport & Prusak (1998); Grant (1996); Leonard-Barton (1995); Nonaka & Takeuchi (1995) for additional discussion.

For firms engaged in (continuous) innovative activities several external sources of knowledge and information are useful. Among those the group of users and consumers attracted considerable research. The role of consumers or users in innovation has been made prominent by Eric von Hippel (1976, 1978, 1994, 2002) and Bengt-Ake Lundvall (1988). Both pay attention to the importance of consumers in the process of generating innovation. Lundvall (1988) focuses on the quality of demand and highlights user-producer relationships as a source of innovative ideas. Consumers contribute their knowledge to the development of complex and specialized equipment, which initiates a process of mutual learning by interacting (Lundvall, 1988). In his empirical study on four different types of new scientific instruments Von Hippel (1976) confirms the user-dominated generation of major improvement innovations. In this context, he raises the point of how to ensure an "accurate understanding of user need" (Von Hippel, 1976) and extends that point to the question on how to organizationally guide customers' needs (Von Hippel, 1978).

Recent work develops these ideas further and discusses the strategic relevance and organizational requirements to integrate innovation-relevant knowledge from customers. The strategic management literature refers to the concept of customer knowledge management (Gibbert et al., 2002; Salomann et al., 2005). The literature on the economics of innovation sees customers as valuable source of external knowledge enhancing innovation activity of firms (Von Hippel, 1976, 1978; Lundvall, 1988) and the organizational needs for customer knowledge integration are discussed in Davenport et al. (1997) and Foss et al. (2006). Besides the absorption of consumer ideas their translation into an adjusted innovation strategy is required. This is especially the case for firms that decide to explicitly orientate their innovation along customers needs.

As a second hypothesis (HYP2) we suggest that firms which want to benefit efficiently from their customer's knowledge have a need for KM measures. Or to put it differently, a consumer–oriented innovation strategy increases the propensity of KM application.

Product life cycle

The design and management of a firm's innovative activity is also driven by the speed of the dynamics in her environment. Progress in science and technology often enforce rapid changes in markets. Firms face a constantly innovating environment where new products are generated with new technologies to meet rising customer demands (Liu et al., 2005). Competitive pressure forces firms to accelerate the introduction of innovations into the market. As a first consequence of this, shorter time to market of a new product and a shortening of product life-cycle (PLC) can be observed: the cycle by which a product passes the phases of birth – growth – maturity – decline (Day, 1981) tends to get shorter and shorter. As a second consequence we observe that increased market dynamics force a

firm to monitor its competitors and customers more intensely. Firms selling products with ever shorter life-cycles experience strong competition, have to respond more quickly to changing markets and face the challenge of forecasting demand (Bayus, 1998). Such kind of increased awareness necessarily requires more and more organisation and management of resources (Earl & Gault, 2003a). This may force a firm to implement organizational practices to successfully cope with these challenges (Salomann et al., 2005).

Recent research on KM uses the speed of innovation or product development and thus the length of the product-life-cycle to measure the success of KM (Liao & Chuang, 2006; Liu et al., 2005). Summarising this, we suggest the following hypothesis (HYP 3): firms forced to cope with products with short lifetimes are more likely to adopt KM measures than firms with products with long lifetimes.

Fluctuation of Employees

The knowledge base of a firm is mainly embodied in its employees. Therefore, any fluctuation of employees directly affects the knowledge base of a firm. The staff turn over will be high in a dynamic environment where high-skilled labour with ever new abilities is needed (Earl & Gault, 2003a). A high fluctuation can either indicate a high loss of employees or a high growth of employees. The former is a signal for the drain of valuable knowledge assets embodied in skilled workers. The loss of key personnel is consequently one of the most important reasons to implement or to increase the use of KM (Earl & Gault, 2003a). Similarly, a high growth of employees may be a sign of an enlargement of the knowledge base through new personnel. Again, there is a need to identify, capture and process the knowledge inside workers heads to make the firm benefiting from this growth of the knowledge base growth (Swan et al., 1999).

We hence hypothesise as HYP 4 that a high fluctuation of employees will increase the necessity of organizing, offering and protecting knowledge within a firm.

2.3.2 General Firm Characteristics

Besides innovation activities of firms there are other firm characteristics that influence the decision to implement KM, notably firm size, multinationality and a firms industry[3].

Size

"For a firm to grow, it must develop organizing principles and a widely-held and shared code by which to orchestrate large numbers of people and, potentially, varied functions" (Kogut & Zander, 1992). A growing or large firm

[3] Size, multinationality and industry will only be included as control variables in the empirical analysis. We thus do not develop formal hypotheses for these variables, but only present an indication of their expected effects.

faces increasing or high organizational requirements due to hierarchies and distributed responsibilities. This implies, that the larger a firm is, the more likely it is that its processes become structured, routinized and deliberately managed. Respective means for processing, storing and distributing knowledge need then to be established. Moreover with increasing size a firm's ability to engage in effective learning processes needs to be managed (Hitt et al., 2000). Hence, an increase in size and thus in the number of skilled workers, requires social as well as technical communication facilitators to ensure cross-departmental communication and to make knowledge accessible everywhere (Swan et al., 1999; Alavi & Leidner, 2001; Gold, 2001). This is even more the case for socialization of ideas during knowledge creation (Nonaka & Takeuchi, 1995). Consequently, it is intuitively clear, that large firms tend to apply more and different KM practices than smaller firms.

This argument is sustained by empirical work. Earl & Gault (2003) show in a Canadian survey on KM that in very small firms with less than 10 employees KM is no objective of managers. With increasing firm size, more formal management practices are introduced. Davenport & Prusak (1998) report that a firm starts to implement a deliberate KM strategy if the firm size exceeds 200-300 employees. Larger firms tend to concentrate also on different KM methods, especially on the documentation of practices and routines and on an advanced communication network (Earl & Gault, 2003). Similar results are found in the KM surveys of France and Germany (Edler, 2003; Kremp & Mairesse, 2003) Thus, with respect to firm size we control for the effect that with increasing size firms tend more to apply KM.

Multinational group of firms

Similar to the influence of size on the application of KM is the influence of the firm's integration in the international economy. Globally acting firms with divers locations around the world have a greater need for a distinctive KM strategy than firms operating only domestically. Multinational enterprises (MNEs) are by their very nature network firms plugging into local centers of technological competence. With respect to the knowledge relations relevant here, two views can be distinguished. First, MNEs are forced to set up operations in various countries to benefit from local competencies and have a need to distribute home-based local knowledge throughout the whole company (Mudambi, 2002). This view is in line with the centre-oriented or home-base mode of knowledge creation discussed in Macharzina et al. (2001), which has its origins in Porter's (1990) diamond model. Second, and opposite Macharzina et al. (2001) emphasize the network-oriented mode of international activities and the need to collect knowledge assets in a decentralized network manner.

No matter, which mode of international activity is applied, in both cases there is a need to organize the access to and sharing of international knowledge resources and skills (Macharzina et al., 2001). The respective challenges related to KM and organizational learning in MNEs are discussed in Nonaka & Takeuchi (1995). They emphasize the extended need for knowledge sharing (socialization of tacit knowledge) efforts and thus mobilization of employees, which is indispensable in knowledge creation across national boundaries. Summarizing, whenever a firm is internationally oriented or a MNE, it should have an additional need to set up KM in order to manage internationally diffused knowledge resources.

Industry

The necessity to organize knowledge in a firm depends not only on the size of the firm and its group structure. What may matter additionally is the industry in which a firm is active in. The creation and exploitation of difficult-to-imitate knowledge assets, and the appropriability regimes vary according to industrial context. Furthermore, some industries are more likely to be challenged by the knowledge economy, like for example multimedia, web services, brokerage, agriculture and biotechnology (Teece, 2000, 44). Less influenced is for example education (partly because of public ownership and limited competition) or low-tech industries like retailing, although partly revolutionalized by new information technologies.

Related to industry, the technology-intensity of a firm's activity is relevant for her efforts to manage her knowledge assets. Hitt et al. (2000) view technology as a form of knowledge, both often interrelated, as for example in biotechnology industry. Thus, they emphasize technological learning and the need of tools for

managing and organising especially technological knowledge. Hence, one may conclude that in particular knowledge- and technology-intensive industries are more likely to apply KM. Indeed, as the OECD studies (Kremp & Mairesse, 2003; Eder, 2003; Earl & Gault, 2003) indicate, knowledge-intensive industries are more likely to apply KM practices. Kremp & Mairesse (2003) for example found in the French part of an OECD study on KM, that KM practices are especially widespread in high and medium high tech industries, as for example pharmacy, aeronautic and electronic component manufacturing. In low-tech industries like clothing, publishing or home equipment KM is less prevalent. In Denmark, particularly service industries apply KM (Baastrup & Strømsnes, 2003). This increased application of KM practices in the service industry is also found in Germany, especially for the business-related and knowledge-intensive services (Eder, 2003). Firms in knowledge-intensive services and high-and medium-high-tech manufacturing are expected to practice KM more frequently.

The discussion so far delivers hypotheses and control variables on the usage on KM and thus provides the basis for an empirical model to be tested. In the following we will analyze in which way the factors identified above determine the application of KM.

3 Data and Empirical Model

To test the hypotheses developed above we use firm-level data from the German innovation survey, the Mannheim Innovation Panel (MIP).[4] This annual survey is conducted by the Centre for European Economic Research (ZEW) in co-operation with infas and Fraunhofer Institute for System- und Innovationresearch (Fh-ISI) on behalf of the German Federal Ministry of Education and Research (bmbf). The definitions and concepts used in the survey, which is targeted at enterprises with at least five employees with headquarters in Germany, are in line with the so called “Oslo Manual” (OECD and Eurostat, 1997).[5] Using a survey that is based on an international standard like the “Oslo Manual” adds an extra layer of quality management. Questions based on the standard concepts have been extensively pre-tested and piloted in various countries, industries and firms with regards to interpretability, reliability and validity (Laursen and Salter, 2006).

Even though the MIP survey is conducted annually in Germany and set-up as a panel, we only analyze cross-sectional data, mainly because the questions needed to construct our independent variables were only included in the questionnaire once, in 2003. The 2003 MIP survey collected data on the innovation activities of

4 A detailed description of the survey can be found in Janz et al. (2001) and Rammer et al., 2005.

5 The CIS surveys and the MIP surveys use the definitions and concepts of the so called “Oslo Manual” (OECD and Eurostat, 1997).

enterprises during the three-year period 2000-2002 with a paper and pencil questionnaire. About 4,500 firms in manufacturing and services responded to the survey.[6] Of those almost 2,000 enterprises indicated that they had introduced at least one product or process innovation in the reference period. We restrict our analysis to firms which introduced innovations between 2000 and 2002 because some of the questions we use to construct our variables are only available for innovating firms, in particular the questions used to construct our measure of knowledge management activities.[7]

3.1 Construction of the variables

The central variable of our study is an indicator for knowledge management activities. We use the appropriate question from the 2003 Mannheim Innovation Panel about internal modes of collaboration in innovation activities between different departments that involve (at least potentially) the exchange of knowledge. We restrict our analysis to those modes that are related to actual management activities and exclude more casual modes like informal contacts, which are hard to generate by management practices. Our KM measure is focused more on face-to-face and interacting modes of collaboration. By this we pay more attention to the demand driven approach of KM and to the non-technical issues related to it. This leaves us with six modes of collaboration: joined development of innovation strategies, open communication of ideas and concepts among departments, mutual support with innovation-related problems, regular meetings of department heads, temporary exchange of personnel, seminars and workshops involving several departments. We take a conservative approach and only label those firms that answered to at least one out of the six measures that they were *highly important* for them during 2000 and 2002, as KM-firms.

In order to estimate the likelihood that a firm uses KM between 2000 and 2002 we specify a probit model with the indicator for KM as the dependent variable and the determinants of KM identified in the literature sections as independent variables.[8]

With regard to our first hypothesis we use information on continuous R&D activities from the questionnaire of the 2003 Mannheim Innovation Panel. For

[6] The sample was drawn using the stratified random sample technique. A comprehensive non-response analysis showed no systematic distortions between responding and non-responding firms with respect to their innovation activities. For a more detailed description of the dataset and the survey see Rammer et al. (2005).

[7] We only have data on knowledge management related to innovation activities (see below for details). This is not a drawback of our study, however, since we do not want to investigate the already confirmed finding that innovative firms are most likely to use KM, but rather which characteristics of the innovating firm do best explain its decision to use KM for innovation activities.

[8] For a detailed description of the construction of all the variables see table 3 in the appendix.

hypothesis 2, the concept of consumer-orientation of innovation activities is operationalised by firms' innovation strategies. We constructed a dummy variable that takes the value one if a firm's strategy is to provide individual solutions for (single) customers. Hypothesis 3 is approached in our model with the industry[9] average (groups of NACE 2 industries[10]) of the product life cycle.

For our fourth hypothesis we use as another measure of dynamics the fluctuation of employees. We include a dummy variable in our model that takes the value one if the firm has experienced a reduction or increase in its employment between 2000 and 2002 that was higher than the 90% percentile (+38 %) of all firms or lower than the 10% percentile of all firms (-17%) in the sample.

Measures for size in terms of employments, industry, belonging to a multinational group are control variables and can directly be constructed from questions in the survey. As additional control variable we use the location in East Germany.[11]

3.2 Descriptive Statistics

The full set of variables necessary to estimate our empirical model is available for 1,738 firms. Of these 1,170 firms (67%) are doing KM according to our definition ("KM firms") and 568 firms (33%) are not ("non-KM firms"). The relative high share of KM firms supports the findings from the literature, that innovative firms (our sample) tend to implement KM more often than firms without innovation activities. The following table provides descriptive statistics for the independent variables used in the probit regression of KM on the explanatory variables.

The descriptive statistics show that there exist differences between the mean of the KM firms and the mean of the non-KM firms. Significant difference can be found for continuous R&D activities, the share of firms having a customer orientation in their innovation activities, belonging to a multinational group, being part of a high-tech manufacturing industries and the product life-cycle of the industry a firm is from.[12] For the size of the firms and the share of firms that experience substantial fluctuation of employees and location in East Germany we do not find differences between firms with KM and those without KM.

[9] We used groups of NACE 2 industries instead of single NACE 2 industries. See appendix for details. Note, the grouping is much more detailed than for our industry dummies included in the model.

[10] See Sofka and Schmidt (2004), p. 25 for a list of NACE 2 groups.

[11] This variable has not been mentioned in the literature review. It is included in our model since it has been shown in many studies that East German and West German firms differ in their innovation activities and strategies (see e.g. Rammer et al. 2005 and Sofka and Schmidt, 2004). It is also a stratification criterion in addition to size and industry.

[12] A correlation table of all the variables for our sample can be found in the appendix (table 4).

Table 1 Descriptive Statistics

Variable	Sample	KM-firms	Non-KM firms	T-Test [A]
Number of observations	1,738	1,170 (67%)	568 (33%)	
Consumer orientation	0.487 (0.500)	0.522 (0.500)	0.415 (0.493)	***
Continuous R&D activities	0.612 (0.487)	0.693 (0.461)	0.447 (0.498)	***
Average product life cycle	9.642 (6.523)	9.442 (6.691)	10.055 (7.882)	*
Number of employees	1,371 (10.758)	1,430 (10,037)	1,252 (12,116)	
Employee fluctuation	0.194 (0.395)	0.196 (0.397)	0.190 (0.393)	
Multinational group	0.252 (0.434)	0.278 (0.448)	0.199 (0.399)	***
East Germany	0.322 (0.467)	0.317 (0.466)	0.331 (0.471)	
Medium-tech manufacturing	0.334 (0.472)	0.343 (0.475)	0.317 (0.466)	
High-tech manufacturing	0.120 (0.325)	0.140 (0.347)	0.077 (0.268)	***
Knowledge Intensive Services	0.320 (0.467)	0.326 (0.469)	0.308 (0.462)	

Standard errors in parenthesis

A) Mean difference between firms with KM and firms without KM:

*** significant at 1% level ; ** significant at 5% level ; * significant at 10% level

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

4 Results

The results of our probit estimation are found in Table 2. We discuss them in turn and start with the innovative activities of firms and the respective hypotheses.

The innovation strategy and orientation of a firm have - as expected - a strong impact on the likelihood that it uses KM tools. Both variables included in our model to capture the nature of innovation activities of firms (continuous research activities and a strong orientation of innovation processes towards customers[13]) are positive and highly significant. Hence, hypotheses 1 and 2 cannot be rejected.

Closely related to the innovation behaviour of firms is the product life-cycle (HYP 3) in an industry. It can be assumed that the more innovations an industry produces, the shorter the product life-cycle will be and the more likely a firm will implement KM tools. In accordance to our hypothesis we find a negative coefficient of the product life-cycle variable; however the coefficient is not significant. Hence we reject hypothesis 3.

A surprising result is the insignificant coefficient for the fluctuation of employees. In Hypothesis 4 we suggest firms with higher fluctuations to have a higher probability to use KM techniques. For the insignificant estimate we forward two explanations: First, our measure of knowledge management focuses on knowledge exchange within the firm between departments and employees. It does not measure the effort firms realize to retain and codify the knowledge of people leaving the firm. The analysed KM tools can potentially be used for training new employees and for organising the exchange of responsibilities between leaving employees and newly hired personal. However, this is not their prime intention. Thus, this may be one reason why employee turnover does not explain the intensified use of KM measures under investigation. Second, the inclusion of small firms in our sample might have influenced our results with respect to the fluctuation variable. Small firms are less likely to have KM, but might exhibit more employee fluctuation than large firms at least in percentage terms, which is the basis for our fluctuation dummy variable.

[13] In an alternative specification we included a dummy variable which takes the value one if a firm has used impulses from customers for its innovation processes. This more general measure of consumer orientation is also highly significant with a coefficient of 0.316 and a marginal effect of 0.119. Full results are available upon request.

Table 2 Probit Estimation – Dependent Variable: KM activities between 2000 and 2002

Variable	Coefficient	Marginal Effect	Robust SEs for Coeffi.	Significance [14]
Consumer orientation	0.185	0.069	(0.064)	***
Continuous R&D activities	0.549	0.208	(0.068)	***
Average product life cycle	-0.003	-0.001	(0.004)	
Size_2: 50-99 employees	0.309	0.111	(0.101)	***
Size_3: 100-249 employees	0.220	0.080	(0.095)	**
Size_4: 250-499 employees	0.197	0.072	(0.118)	*
Size_5: 500+ employees	0.374	0.133	(0.104)	***
Employee fluctuation	0.004	0.001	(0.064)	
Multinational group	0.058	0.022	(0.084)	
East Germany	0.049	0.018	(0.069)	
Medium-tech manufacturing	0.080	0.030	(0.004)	
High-tech manufacturing	0.385	0.135	(0.124)	***
Knowledge Intensive Services	0.271	0.100	(0.088)	***
Constant	-0.411	-	(0.107)	***
Number of Observations	1,738			
Log Likelihood	-1,076.35			

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.

Concerning the influence of other firm characteristics on the likelihood to apply KM we at first look at size. Similar to others (e.g. Swan et al, 1999; Earl & Gault, 2003) we find that larger firms are more likely to use KM than smaller firms. Our model includes four dummies for different size classes of firms. All four dummies are significant indicating that firms with more than 50 employees have a higher likelihood to have KM than firms with less than 50 employees. Looking at the marginal effects on the other dummies we find the highest for firms with 500+ employees and the second highest for firms with 50-99 employees, with the coefficients for size_2 and size_3 in between. This can be seen as an indicator for a non-linear relationship between size and KM.[15]

We find no evidence for a significant effect of being part of a multinational group.[16] Since size is significantly influencing the probability to apply KM, this

[14] *** significant at 1% level ; ** significant at 5% level ; * significant at 10% level

[15] The estimation of an alternative model not reported in the paper with the log of the number of employees and the squared term of the log of the number of employees instead of size dummies included, also shows that there is a non-linear relationship between size and the likelihood for KM.

[16] To check the robustness of our results we estimated an alternative model with a dummy variable for being part of a group. The level of significance for the size variable does not change. What is more, the estimated coefficients for the size variables are almost identical.

variable perhaps captures the impact of being part of a group already. Then again, none of the correlation coefficients between the size variables and the multinational dummy is above 0.50.

With regard to the influence of a firms' industry of main activity, we can confirm former empirical findings (Eder, 2003; Kremp & Mairesse, 2003). High-tech manufacturing and knowledge intensive service industries are more likely to use KM techniques than firms from other industries.

Finally, East and West German firms do not seem to differ with respect to the usage of KM techniques, even though the environment they operate is different in some respect. The variable for location of the firm in East Germany is positive but not significant. It is noteworthy in this respect, that we did not measure the intensity or scope of KM with our dependent variable, but only the existence. It can be expected that East German firms use KM less intensively, but we leave that to further research.

5 Implications and Concluding Remarks

In this study we investigate the determinants of knowledge management using a large scale survey of innovative German firms. We find that the innovation strategy of a firm is one of the main drivers of the usage of KM, underscoring the link between KM and the amount and quality of knowledge a firm has to deal with. Continuous research and development and with it continuous production of high quality knowledge increases the probability of KM usage. Another implication of this finding is that even in the innovation process, which is usually governed by uncertainty and trial and error, routinized behaviour is present (Coombs & Hull, 1997; Webster, 2004). Search for internal knowledge assets or creativity meetings, which are included in our list of KM tools, seem to become structured and organized parts of the innovation process.

The finding that KM is linked to the amount and quality of knowledge necessary to be successful as a firm is reinforced by the finding that firms in high-tech manufacturing and knowledge-intensive services are most likely to implement KM tools and to evaluate them as highly important for the firm. The latter finding can also be seen as evidence for the knowledge economy, which forces firms to deliberately manage their knowledge, to become active (instead of reactive) knowledge players and to face rapid knowledge redundancy (Grant, 1996; Lundvall, 2006; Nonaka et. al., 2000).

Focusing on leading-edge users becomes more and more essential for innovating firms (Rothwell, 1994). Our results show that a consumer-oriented innovation strategy that takes this into account, basically referring to the market

pull approach of innovation (Hayes & Abernathy, 1980; Rothwell, 1994), increases the probability to deploy above average KM tools. KM seems to be one way to deal with the great amount of (sometimes useless) impulses from customers and filter out the truly valuable ones.

Besides these strong finding on innovation activities we can reason, that the need for KM is also linked with more general firm characteristics. Firms' size and KM are positively related, employee fluctuating seems to be not related to KM.

External environmental dynamics, captured by product life-cycle at the industry level (and being located in East Germany) does hint neither on elaborated KM application nor on its importance for the firm. Thus, it looks like firms do not consistently appreciate KM as an appropriate way to handle external pressure. However the firms' industry of main activity as an explanatory determinant of KM application hints on industry-specificities.

Due to data restriction we had to limit our definition of KM to the collaborative aspects of KM in firms. It is however necessary to enlarge the focus on knowledge transfer, creativity and storage efforts in firms and investigate the determinants of and complementarities between all of these different groups of KM techniques.

Taking all these results together our paper emphasises the relevance of the demand-based approach of KM for understanding the innovating firm. Hence, despite innovation being an uncertain and spontaneous creation of new knowledge, we find KM as important tool to manage innovation activities. KM represents the routinised element of the innovation process. KM activities seem to help making the innovation process less uncertain and more targeted. The more firms continuously attempt to innovate, the more a firm's activities are related to high-tech and knowledge-intensive services, and the more innovative activities require information from outside the firm (customers) the higher seems the need to establish appropriate KM measures.

6 Literatur

Alavi M., Leidner D. (2001), Review: Knowledge Management and Knowledge Management Systems: Conceptual Foundations and Research Institutes, *MIS Quarterly*, Vol. 25, No. 1, 107-136

Audretsch D.B., Feldman M.P. (1996), Innovative Clusters and the Industry Life Cycle, *Review of Industrial Organization*, 11, 253-273

Baastrup A., Strømsnes W. (2003), The Promotion and Implementation of Knowledge Management - A Danish Contribution, In: OECD/Minister of Industry Canada (Ed.), *Measuring Knowledge Management in the Business Sector*, Ch. 5, 119-141

Barney J.B. (1991), Firm resources and sustained competitive advantage, *Journal of Management*, 17, 99-120

Bayus B.L. (1998), An Analysis of Product Lifetimes in a Technologically Dynamic Industry, *Management Science*, Vol. 44, No. 6, 763-775

Bharadwaj A.S. (2000), A resource-based perspective on Information Technology capability and firm performance: An empirical investigation, *MIS Quarterly*, Vol. 24, No. 1, 169-196

Coombs R., Hull R. (1998), Knowledge management practices' and path-dependency in innovation, *Research Policy*, 27, 237-253

Davenport T.H., Prusak L. (1998), *Working Knowledge*, Harvard Business School Press, Boston

Davenport T.H., De Long D.W., Beers M.C. (1997), *Building Successful Knowledge Management Projects*, Center for Business Innovation Working Paper

Day G.S. (1981), The Product Life Cycle: Analysis and Applications Issues, *Journal of Marketing*, Vol. 45, No. 4, 60-67

Desouza K., Evaristo R. (2003), Global Knowledge Management Strategies, *European Management Journal*, Vol. 21, No. 1, 62-67

Dick M., Wehner T. (2002), Wissensmanagement zur Einführung: Bedeutung, Definition, Konzepte, in: Lüthy, W., E. Voit, T. Wehner (Eds.), *Wissensmanagement-Praxis. Einführung, Handlungsfelder und Fallbeispiele*, Zürich: vdf, 7-27

Earl L. (2003), Are we Managing our Knowledge? The Canadian Experience, In: OECD/Minister of Industry Canada (Ed.), *Measuring Knowledge Management in the Business Sector*, Ch. 3, 55-85

Earl L., Gault F. (2003), Knowledge Management: Size Matters, In: OECD/Minister of Industry Canada (Ed.), *Measuring Knowledge Management in the Business Sector*, Ch. 7, 169-186

Edler J. (2003), The Management of Knowledge in German Industry, In: OECD/Minister of Industry Canada (Ed.), *Measuring Knowledge Management in the Business Sector*, Ch. 4, 89-118

Eisenhardt K.M., Martin J.A. (2000), Dynamic capabilities: What are they?, *Strategic Management Journal*, 21, 1105-1121

Gibbert M., Leibold M., Probst G. (2002), Five Styles of Customer Knowledge Management, and How Smart Companies Use Them To Create Value, *European Management Journal*, Vol. 20, No. 5, 459-469

Gold A.H., Malhorta A., Segars A.H. (2001), Knowledge Management: An Organizational Capabilities Perspective, *Journal of Management Information Systems*, Vol. 18, No. 1, 185-214

Grant E.B., Gregory M.J. (1997), Tacit Knowledge, the Life Cycle and International Manufacturing Transfer, *Technology Analysis & Strategic Management*, Vol. 9, No. 2, 149-161

Grant R.M. (2001), The knowledge-based view of the firm, in: Bontis, N. & C.W. Choo (Eds.) *The Strategic Management of Intellectual Capital and Organizational Knowledge: A Collection of Readings*, Oxford University Press, New York

Grant R.M. (1996), Toward a knowledge-based view of the firm, *Strategic Management Journal*, 17 (Winter Special Issue), 109-122

Grant R.M. (1996), Prospering in Dynamically-competitive Environments: Organizational Capability as Knowledge Integration, *Organization Science*, Vol. 7, No. 4, 375-387

Hall R. (1993), A framework linking intangible resources and capabilities to sustainable competitive advantage, *Strategic Management Journal*, 14, 607-618

Hall R., Andriani P. (2002), Managing Knowledge for Innovation, *Long Range Planning*, 35, 29-48

Hargadon A.B. (1998), Firms as Knowledge Brokers: Lessons in Pursuing Continuous Innovation, *California Management Review*, Vol. 40, No. 3, 209-227

Hitt M.A., Ireland R.D., Lee H. (2000), Technological learning, knowledge management, firm growth and performance: an introductory essay, *Journal of Engineering and Technology Management*, 7, 231-246

Holsapple C.W., Singh M. (2001), The knowledge chain model: activities for competitiveness, *Expert Systems with Applications*, 20, 77-98

Howells J. (1996), Tacit Knowledge, Innovation and Technology Transfer, *Technology Analysis & Strategic Management*, Vol. 8, No. 2, 91-105

Huergo E. (2006), The role of technological management as a source of innovation: Evidence from Spanish manufacturing firms, *Research Policy*, 35, 1377-1388

Hurley R.F., Hult T.M. (1998), Innovation, Market Orientation, and Organizational Learning: An Integration and Empirical Examination, *Journal of Marketing*, 62, 42-54

Johannessen J.A., Olaison J., Olsen B. (2001), Mismanagement of tacit knowledge: the importance of tacit knowledge, the danger of information technology, and what to do about it, *International Journal of Information Management*, 21, 3-20

Kogut B., Zander U. (1992), Knowledge of the firm, combinative capabilities, and the replication of technology, *Organization Science*, Vol. 3, No. 3, 383-397

Kremp E., Mairesse J. (2003), Knowledge Management, Innovation and Productivity: A Firm Level Exploration Based on French Manufacturing CIS3 Data, In: OECD/Minister of Industry Canada (Ed.) *Measuring Knowledge Management in the Business Sector*, Ch. 6, 143-168

Laursen K., Salter A. (2006), Open for Innovation: The Role of Openness in Explaining Innovation Performance among U.K. Manufacturing Firms, *Strategic Management Journal* 27 (2), 131-150

Liao C., Chuang S.H. (2006), *Exploring the Role of Knowledge Management for Enhancing Firm's Innovation and Performance*, Proceedings of the 39th Hawaii International Conference on System Sciences - 2006

Liu P.L., Chen W.C., Tsai C.H. (2005), An empirical study on the correlation between the knowledge management method and new product development strategy on product performance in Taiwan's industries, *Technovation*, 25, 637-644

Lundvall B.-A. (1988), Innovation as an interactive process: from user-producer interaction to the national system of innovation, in: Dosi G., Freemann Ch., Nelson R., Silverberg G. L. Soete (Eds): *Technical Change and Economic Theory*, London, Pinter Publishers, Chapter 17, 346–369

Lundvall B.-A. (2006), *Knowledge Management in the Learning Economy*, DRUID Working Paper, 06-6

Macharzina K., Oesterle M.J., Brodel D. (2003), Learning in Multinationals, in: Dierkers M., Antal A.B., Child J., Nonaka I. (Eds.), *Handbook of Organizational Learning and Knowledge*, Oxford University Press, Oxford

Mandl H., G. Reinmann-Rothmeier (2000), *Wissensmanagement. Informationszuwachs - Wissensschwund? Die strategische Bedeutung des Wissensmanagements*, R.Oldenburg Verlag, München

March J.G. (1991), Exploration and Exploitation in Organizational Learning, *Organizational Science*, Vol. 2, No. 1, 71-87

Mudambi R. (2002), Knowledge management in multinational firms, *Journal of International Management*, 8, 1-9

Nonaka I. (1994), A Dynamic Theory of Organizational Knowledge Creation, *Organization Science*, Vol. 5, No. 1, 14-37

Nonaka I., Takeuchi H. (1995), *The Knowledge-Creating Company. How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press Oxford

Nonaka I., Toyama R., Konno N. (2000), SECI, 'Ba' and Leadership: a Unified Model of Dynamic Knowledge Creation, *Long Range Planning*, 33, 5-34

OECD and Eurostat (1997), *Oslo Manual - Proposed Guidelines for Collecting and Interpreting Technological Innovation Data - 2nd Edition*, Paris

Probst G., Raub S., Romhardt K. (1999) Wissen managen. Wie Unternehmen ihre wertvollste Ressource optimal nutzen, Frankfurt am Main, 1999

Qualls W., Olshavsky R.W., Michaels R.E. (1981), Shortening of the PLC - An empirical test, *Journal of Marketing*, Vol. 45, No. 4, 76-80

Rammer C., Peters B., Schmidt T., Aschhoff B., Doherr T., Niggemann H. (2005), *Innovationen in Deutschland - Ergebnisse der Innovationserhebung 2003 in der deutschen Wirtschaft*, ZEW Wirtschaftsanalysen Band 78, Nomos Verlagsgesellschaft, Baden-Baden

Rothwell R. (1994), Towards the Fith-generation Innovation Process, *International Marketing Review*, Vol. 11, No. 1, 7 - 31

Rumelt R.P. (1984), Towards a strategic theory of the firm, In: Lamb, R. (Ed) *Competitive Strategic Management*, Englewood Cliffs, New Jersey, 566-570

Salomann H., Dous M., Kolbe L., Brenner W. (2005), Rejuvenating Customer Management: How to Make Knowledge *For*, *From* and *About* Customers Work, *European Management Journal*, Vol. 23, No. 4, 392-403

Spender J.C. (1996), Organizational knowledge, learning and memory: thee concepts in search of a theory, *Journal of Organizational Change Management*, Vol. 9, No. 1, 63-78

Sofka W., Schmidt T. (2004), *I like the way you move – An Empirical Investigation into the Mechanisms Behind First Mover and Follower Strategies* , ZEW Discussion Paper No. 04-87, Mannheim.

Swan J., Newell S., Scarbrough H., Hislop D. (1999), Knowledge management and innovation: networks and networking, *Journal of Knowledge Management*, Vol. 3, No. 4, 262-275

Teece D.J. (2000), Strategies for Managing Knowledge Assets: the Role of Firm Structure and Industrial Context, *Long Range Planning*, 33, 35-54

Teece D., Pisano G. (1994), The Dynamic Capabilities of Firms: an Introduction, *Industrial and Corporate Change*, Vol. 3, No. 3, 537-555

Teece D.J., Pisano G., Shuen A. (1997), Dynamic capabilities and strategic management, *Strategic Management Journal*, 18, 509-533

Utterback J.M., Abernathy W.J. (1975), A Dynamic Model of Process and Product Innovation, *OMEGA*, Vol. 3, No. 6, 639-656

Van Aken J.E., Weggeman M.P. (2000), Managing learning in informal innovation networks: overcoming the Daphne-dilemma, *R&D Management*, Vol. 30, No. 2, 139-149

Von Hippel E. (1976), The dominant role of users in the scientific instrument innovation process, *Research Policy*, 5, 212-239

Webster E. (2004), Firms' Decision to Innovate and Innovation Routines, *Economics of Innovation and New Technology*, Vol. 13 (8), 733-745

Wernerfelt B. (1984), A Resource-Based View of the Firm, *Strategic Management Journal*, Vol. 5, No. 2, p. 171-180

Yang J. (2005), Knowledge integration and innovation: Securing new product advantage in high technology industry, *Journal of High Technology Management Research*, 16, 121-135

7 Appendix

Table 3 Construction of the Variables

Variable Name	**Type**	**Description**
Size	Dummies	Size_1 (Reference): 5-49 employees Size_2: 50-99 employees Size_3: 100-249 employees Size_4: 250-499 employees Size_5: 500+ employees
Employee fluctuation	Dummy	One, if the growth of employees between 2000 and 2002 was higher than the 75% percentile (+13.5 %) of all firms or lower than the 25% percentile of all firms (-7%).
Consumer orientation	Dummy	One, if the firm's strategy between 2000 and 2002 is to provide individual solutions for customers.
Continuous R&D activities	Dummy	One, if the firm is engaged in R&D activities on a continuous basis.
Multinational group	Dummy	One, if the firm belongs to a multinational group.
East Germany	Dummy	One, if the firm is located in East Germany.
Average product life cycle	Index	Average length of the product life-cycle in years.
Medium-tech manufacturing	Dummy	One, if the firm belongs to NACE 23-24 (excl. 244), 29, 31, 34-35 (excl. 353)
High-tech manufacturing	Dummy	One, if the firm belongs to NACE 244, 30, 32, 33, 353
Knowledge Intensive Services	Dummy	One, if the firm belongs to NACE 65-67, 74.1, 74.4

Table 4 Correlation Table for Independent Variables

Variable		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Consumer orientation	(1)	-	0.092	-0.014.	0.039	-0.032	-0.029	-0.132	-0.011	-0.083	0.019	0.017	0.045	0.020
Continuous R&D activities	(2)		-	-0.033	-0.022	-0.021	0.028	0.115	-0.001	0.149	-0.012	0.193	0.206	-0.116
Average product life cycle	(3)			-	-0.003	-0.010	0.059	0.061	-0.012	0.034	-0.015	0.121	-0.099	-0.159
Size_2: 50-99 employees	(4)				-	-0.179	-0.129	-0.189	0.002	-0.047	0.040	-0.010	-0.013	-0.005
Size_3: 100-249 employees	(5)					-	-0.145	-0.212	-0.046	0.078	-0.024	0.056	0.025	-0.111
Size_4: 250-499 employees	(6)						-	-0.154	-0.049	0.097	-0.055	0.096	-0.024	-0.115
Size_5: 500+ employees	(7)							-	-0.063	0.3855	-0.202	0.078	-0.005	-0.083
Employee fluctuation	(8)								-	-0.015	0.032	-0.098	0.061	0.092
Multinational group	(9)									-	0.034	0.179	0.039	-0.140
East Germany	(10)										-	-0.049	0.035	0.040
Medium-tech manufacturing	(11)											-	-0.261	-0.486
High-tech manufacturing	(12)												-	-0.2529
Knowledge Intensive Services	(13)													-

Source: ZEW (2005): Mannheim Innovation Panel, own calculations.