# The use of knowledge management by German innovators

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The authors would like to thank the ZEW for providing access to the data and support for a research visit by Tobias Schmidt to Jena. Kristin Joel would like to thank the VW foundation for support of 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. The authors also thank Sidonia von Ledebur and two anonymous referees for valuable suggestions and contributions with regard to the quality and style of our paper. The paper represents the authors' personal opinions and do not necessarily reflect the views of the Deutsche Bundesbank or its staff.

**Abstract**

**Purpose** – *The purpose of this paper is to uncover factors that influence a firm's decision to implement knowledge management practices. The focus is on knowledge management practices implemented to increase collaboration on innovation activities between actors within a firm.*

**Design/methodology/approach** – *Empirical analysis (probit estimations) of survey data on over 1,500 innovative German firms from the Mannheim Innovation Panel of 2003.*

**Findings** – *The paper finds that an innovation strategy targeted at consumers and continuous R&D activities are positively related to knowledge management usage by innovative German firms. In addition, more general characteristics like the size and the industry of a firm also influence the decision to use knowledge management.*

**Research limitations/implications** – *Given data restrictions the paper only analyses the collaborative aspects of knowledge management in firms. Future research should also take into account knowledge transfer, creativity, storage efforts in firms and IT related aspects of knowledge management and investigate the determinants of and complementarities between all of these different techniques. The paper is limited in both the time period it analyses and regional scope. Further research is necessary to investigate whether the results also hold for other countries and other periods.*

**Originality/value** – *The analysis in this paper contributes to the existing literature by investigating the determinants of firms' decisions to engage in knowledge management activities using a large-scale survey of firms from a variety of different industries. The data used grant a unique insight into the innovation activities of firms and knowledge management approaches connected to these activities.*

**Keywords** *Knowledge management, Innovation, Estimation*

**Paper type** *Research paper*

## 1. Introduction

The use of knowledge management (KM) is not restricted to large companies or firms whose business is knowledge. Nowadays almost every firm in the industrialised 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 organise 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 such a way that they become a difficult-to-imitate source of a firm's competitive advantage. Consequently, an important implication is that every firm that is part of the knowledge economy should show a sustained interest in practicing some form of KM. The implementation of KM, however, is costly in the sense that it usually involves a number of changes, such as restructuring firm hierarchies, breaking habits and routines, learning and using new information and communication technologies. Hence, firms that consider such

costs too high will not make the effort and apply KM practices. This raises an obvious question: which firms actually practice KM and what characteristics do these firms have?

An increasing amount of literature emphasises KM as firms' major challenge for the future (Hall and Andriani, 2002; Nonaka and Takeuchi, 1995; Lundvall, 2006; Yang, 2005). Furthermore, recent KM studies, concentrating on fairly small samples, discuss KM predominantly in the context of strategic management decisions (Alavi and Leidner, 2001; Gold *et al.*, 2001; Yang, 2005).

Building on this literature, an empirical model to analyse the key characteristics which increase firms' propensity to apply KM is established. Besides size and industry indicators capturing the internal dynamics a firm faces are investigated. The empirical results for a large sample of German firms confirm that large firms in knowledge-intensive industries with a continuous and consumer-oriented innovation strategy are particularly likely to employ a KM strategy.

The paper is structured as follows. First, in section 2, a literature review is provided, which concentrates on the factors that lead firms to adopt KM. This review allows selecting potential major determinants of KM, which serve as constituting elements of the empirical model. In section 3 the analytical framework is introduced. Section 4 contains a description of the data and the selected variables. Section 5 discusses the estimation results, followed by a conclusion in section 6.

## 2. Literature review

What determines a firm's propensity to implement a KM strategy? In this paper an attempt is made to answer this question on the basis of the knowledge management literature. Definitions of KM are reviewed first, followed by a discussion of promoters of KM providing incentives for a firm to organise a set of knowledge processing operations and routines. On the one hand, the knowledge economy is seen as an external KM promoter, which influences every firm within this economy. On the other hand, certain firm characteristics may function as internal promoters facilitating a deliberate KM strategy. The latter is discussed first.

### *2.1. Knowledge management*

The process of managing organisations' existing knowledge is an ancient phenomenon and not new in the portfolio of management activities. Using employees' competences and combining them into organisational capabilities is a requirement 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 whose main aim is to use the strategic resource knowledge more deliberately and more efficiently. Swan *et al.* (1999, p. 264) also stick to a fairly 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 and Hull, 1998; Holsapple and Singh, 2001). According to Swan *et al.* (1999), KM practices can be divided into IT-based or supply-driven and demand-driven approaches.

Supply-driven KM is implemented using 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 and Leidner, 2001) and tools that organise the storage, usage and transfer of knowledge and information. In this sense KM represents those of a firm's infrastructure capabilities which enhance the acquisition and distribution of explicit or codified knowledge (Gold *et al.*, 2001). The importance these infrastructural capabilities

have for most firms nowadays cannot be denied. However, two constraints have to be considered. First, infrastructure with which to share and distribute information and knowledge is only one aspect of successful KM, others are the willingness, incentives, motivations of people to use it. Thus, supply-driven approaches take no account of the cultural and social facets of KM (Alavi and Leidner, 2001). Second, KM has the ability to integrate knowledge and information in such a way as to generate a firm-specific resource – a unique knowledge and competence base. IT infrastructure alone cannot accomplish this. All firms can buy and implement IT infrastructure; it cannot therefore be a source of competitive advantage (Johannessen *et al.*, 2001).

The demand-driven approach to KM is concerned with the human and managerial aspects of KM (Davenport and Prusak, 1998; Nonaka and Takeuchi, 1995; Swan *et al.*, 1999). The focus here lies more on the cultural and social dimension of creating, sharing and applying knowledge. The aim of KM practices is to crystallise, exchange and apply knowledge, often located in people's heads, for innovation. In this context tacit knowledge, which is often highly relevant for innovation is particularly important. 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 a resource. IT infrastructure may obviously serve as a supportive tool but it cannot substitute demand-driven practices.

Despite a wide range of KM definitions and practices it becomes apparent that a KM strategy concentrating on innovation should encompass, in particular, the demand-driven and knowledge sharing approaches to KM. Therefore attention will be paid to a firm's knowledge creation and sharing activities to identify firms with KM in the dataset used in the empirical part of the paper.

### *2.2. The knowledge economy: external promoter of KM application*

Looking at the determinants that lead firms to implement KM, the authors first refer to external promoters. Here, they consider the knowledge economy on the one hand and the learning economy on the other. Both deem knowledge and knowledge creation to be 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 borders and distances without decelerating. Information is increasingly digital and virtual. All these 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 of knowledge becoming obsolete more rapidly. Thus, it is necessary for firms to forget old and obtain new knowledge and competences 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 from which to draw strategic conclusions. The managerial requirements here are different from those in bygone eras. Whereas in former times access to physical assets was key to gaining a competitive advantage, in the knowledge society it is access to knowledge, to competences and to creativity. Firms have more needs that must be met and problems that need to be solved using knowledge than before (Nonaka *et al.*, 2000). They not only process information but 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 realise that knowledge is their source of sustainable competitive advantage and highest quality power in order to succeed in mastering rapid change (Teece, 2000).

> **"Despite a wide range of KM definitions and practices it becomes apparent that a KM strategy concentrating on innovation should encompass, in particular, the demand-driven and knowledge sharing approaches."**

Both the knowledge and the learning economies require organisational capabilities to anticipate and manage the dynamics of change (Eisenhardt and 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.

This part of the literature review yields no formal hypothesis to be tested empirically, since it is quite hard to measure a particular firm's general exposure to the knowledge economy using more general variables. However, the indicators of firms' innovation behaviour discussed below will, to a certain degree, help to assess the importance of knowledge for a firm.

### *2.3. Firm characteristics: internal promoter of KM application*

The aim in the previous section has been to show that the characteristics and growing importance of the knowledge economy give rise to a general need for KM. Complementary to this external pressure for KM, the relevant literature shows, that a firm's inherent characteristics – which are the focus of the empirical analysis below – may create a need for KM.

This argument is founded 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 attitude towards the use of knowledge (Barney, 1991). In general they differ in their knowledge-intensity of production and thus in their dependence on knowledge and their need to implement KM. In the following the authors identify various factors related to firms' knowledge requirements. Based on these findings, hypotheses about the factors which determine whether firms implement KM are developed.

*2.3.1. Characteristics of innovation activities and firms' knowledge bases.* A vast amount of literature has discussed KM and its relevance for innovation activities. Here, only the literature that focuses on the consumer-orientation of innovation activities and continuous R&D activities is reviewed. The interested reader can turn to, e.g. Coombs and Hull (1998); Davenport and Prusak (1998); Grant (1996a); Leonard-Barton (1995); Nonaka and Takeuchi (1995) for additional discussion.

*Continuity of innovative activity.* Innovative activities are one way for firms to achieve a competitive advantage (Grant, 1996a; Nonaka and Takeuchi, 1995; Utterback and 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 is often a path-dependent result of the continuous and repeated reconfiguration of knowledge. This implies that further innovative success draws heavily on a firm's accumulated knowledge base. Second, continuous innovation requires receptiveness to changes in the market, in technology, competition or products. Consequently, successful companies regard 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 and 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 and Hull, 1998; Webster, 2004; Grant, 1996b).

Empirical evidence on this relationship is presented in Hargadon (1998) and Liao and Chuang (2006). They all argue that firms adopting KM continuously develop new products or new processes. As Hargadon (1998) shows this applies even more to so-called ''knowledge brokers''. Knowledge brokers are firms seen as the modern invention factories, specialised in continuously producing innovative solutions to novel problems. They essentially relate the innovative ideas of one industry to new problems occurring in another industry (Hargadon, 1998; Mandl and Reinmann-Rothmeier, 2000). The main 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 organisational support for exchanging ideas and gate-keeping activities becomes quite obvious.

The first hypothesis (*H1*) is 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*. For firms engaged in (continuous) innovative activities, several external sources of knowledge and information are useful. Of these, the group of users and consumers has 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 innovations. 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 specialised 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 guide customers' needs organisationally (Von Hippel, 1978).

Recent work develops these ideas further and discusses the strategic relevance of and organisational requirements for integrating innovation-relevant knowledge obtained 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 a valuable source of external knowledge enhancing firms' innovation activity (Von Hippel, 1976, 1978; Lundvall, 1988), and the organisational need for customer knowledge integration is discussed in Davenport *et al.* (1997) and Foss *et al.* (2006). Consumer ideas must not only be absorbed, they must also be translated into an adjusted innovation strategy. This is especially true of firms that decide to explicitly orientate their innovation to meet customers' needs.

The second hypothesis (*H2*) is that firms which want to benefit efficiently from their customers' knowledge have a need for KM measures. Or to put it differently, a consumer-oriented innovation strategy increases the propensity to apply KM.

*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, new products can be observed to have a shorter time to market and product life cycles (PLC) shorten: 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, 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 increased awareness necessarily requires more and more organisation and management of resources (Earl and Gault, 2003a). This may force a firm to implement organisational practices to successfully cope with these challenges (Salomann *et al.*, 2005).

> **"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'."**

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 and Chuang, 2006; Liu *et al.*, 2005). This is summarised in the following hypothesis (*H3*): firms forced to cope with products characterized by short lifespans are more likely to adopt KM measures than firms with products of long lifespans.

*Fluctuation of employees.* A firm's knowledge base is mainly embodied in its employees. Therefore, it is directly affected by any fluctuation of employees. Staff turnover will be high in a dynamic environment where highly-skilled labour with ever new abilities is needed (Earl and Gault, 2003a). High fluctuation can either indicate a high loss of employees or a high growth of employees. The former indicates 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 and Gault, 2003a). Similarly, a large number of new employees may be a sign that the knowledge base has been enlarged through new personnel. Again, the knowledge inside workers' heads needs to be identified, captured and processed to make the firm benefit from this growth of the knowledge base (Swan *et al.*, 1999).

Hence Hypothesis four (*H4*) is: a high fluctuation of employees will increase the necessity of organising, disseminating and protecting knowledge by KM within a firm.

*2.3.2. General firm characteristics.* Besides their innovation activities, there are other characteristics that influence a firm's decision to implement KM, notably firm size, multinationality and the industry in which it operates. Measures for these characteristics are included as control variables in our analysis.

*Size.* ''For a firm to grow, it must develop organising principles and a widely-held and shared code by which to orchestrate large numbers of people and, potentially, varied functions'' (Kogut and Zander, 1992). A growing or large firm faces increasing or high organisational requirements due to hierarchies and distributed responsibilities. This implies that the larger a firm, the more likely its processes are to become structured, routinised 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 and Leidner, 2001; Gold *et al.*, 2001). This is even more the case for the socialisation of ideas during knowledge creation (Nonaka and 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 and Gault (2003) show in a Canadian survey on KM that in very small firms with less than ten employees KM is no objective for managers. With increasing firm size, more formal management practices are introduced. Davenport and Prusak (1998) report that a firm starts to implement a deliberate KM strategy if the firm size exceeds 200-300 employees. Larger firms also tend to concentrate on different KM methods, especially on the documentation of practices and routines and on an advanced communication network (Earl and Gault, 2003). Similar results are found in the KM

surveys of France and Germany (Edler, 2003; Kremp and Mairesse, 2003). Including firm size in the empirical model therefore controls for the fact that, with increasing size, firms are more likely to apply KM.

*Multinational group of firms*. The influence of the firm's integration in the international economy on the application of KM is similar to the influence of size. Globally operating firms with diverse 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 centres 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.* (2003), which has its origins in the diamond model of Porter (1990). Second, and by way of contrast, Macharzina *et al.* (2003) emphasise the network-oriented mode of international activities and the need to collect knowledge assets in a decentralised network manner.

Regardless of which mode of international activity is applied, access to and the sharing of international knowledge resources and skills need to be organised (Macharzina *et al.*, 2003). The respective challenges related to KM and organisational learning in MNEs are discussed in Nonaka and Takeuchi (1995). They emphasise the extended need for knowledge sharing (socialisation of tacit knowledge) efforts and thus mobilisation of employees, which is indispensable in knowledge creation across national boundaries. Summarising, whenever a firm is internationally oriented or an MNE, it is likely to have an additional need to set up KM in order to manage internationally spread knowledge resources.

*Industry*. The necessity of organising knowledge in a firm depends not only on the size of the firm and its group structure. What may also be relevant is the industry in which a firm is active. The creation and exploitation of difficult-to-imitate knowledge assets and the appropriability regimes vary according to industry context. Furthermore, some industries are more likely to be challenged by the knowledge economy, for example multimedia, web services, brokerage, agriculture and biotechnology (Teece, 2000, p. 44). Education, for example, is less influenced (partly because of public ownership and limited competition) as are low-tech industries like retailing, although they too have, to some extent, been revolutionalised by new information technologies.

Related to industry, the technology intensity of a firm's activity is relevant to 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 the biotechnology industry. Thus, they emphasise technological learning and the need for tools to manage and organise technological knowledge in particular. Hence, one may conclude that knowledge and technology-intensive industries in particular are more likely to apply KM. As the OECD studies (Kremp and Mairesse, 2003; Edler, 2003; Earl and Gault, 2003) indicate, knowledge-intensive industries are indeed more likely to apply KM practices. Kremp and Mairesse (2003) for example found in the French part of an OECD study on KM, that KM practices are especially widespread in high-tech and medium high-tech industries such as pharmacy, aeronautics and electronic component manufacturing. In low-tech industries like clothing, publishing or home equipment, KM is less prevalent. In Denmark, service industries in particular apply KM (Baastrup and Strømsnes, 2003). This increased application of KM practices in the service industry is also found in Germany, especially for business-related and knowledge-intensive services (Edler, 2003). Firms in knowledge-intensive services and high-tech and medium high-tech manufacturing are expected to practice KM more frequently.

The discussion so far delivers hypotheses on and control variables for the usage on KM and thus provides the basis for an empirical model to be tested. In the following, how the factors identified above determine the application of KM is analysed.

## 3. Data and empirical model

To test the hypotheses developed above, firm-level data from the German innovation survey, the Mannheim Innovation Panel (MIP), is used (Janz *et al.,* 2001 and Rammer *et al.*, 2005). This annual survey is conducted by the Centre for European Economic Research (ZEW) in co-operation with infas and the Fraunhofer Institute for Systems and Innovation Research (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 and headquartered in Germany, are in line with the so-called ''Oslo Manual'' (OECD and Eurostat, 1997). Using a survey that is based on an international standard like the ''Oslo Manual'' adds an extra layer of quality management. Questions based on standard concepts have been extensively pre-tested and piloted in various countries, industries and firms with regard to interpretability, reliability and validity (Laursen and Salter, 2006).

Though the MIP survey is conducted annually in Germany and is set up as a panel, only cross-sectional data is analysed here, 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 enterprises during the three-year period 2000-2002 using a paper-and-pencil questionnaire. 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 (Rammer *et al.*, 2005). About 4,500 firms in manufacturing and services responded to the survey. Of those almost 2,000 enterprises indicated that they had introduced at least one product or process innovation in the reference period. The analysis is restricted to firms which introduced innovations between 2000 and 2002 because some of the questions used to construct the variables were only asked of innovating firms, in particular the questions used to construct the measure of knowledge management activities.

For the analysis in this paper only data on knowledge management related to innovation activities is available (see below for details). This is not a drawback for this study, however, since the authors do not want to investigate the already confirmed finding that innovative firms are most likely to use KM, but rather determine which of the innovating firm's characteristics best explain its decision to use KM for innovation activities.

### *3.1. Construction of the variables*

The central variable of this study is an indicator of knowledge management activity. This variable is created using 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. The analysis is limited to those modes that are related to actual management activities, and more casual modes such as informal contacts, which are hard to influence by management practices, are excluded. The KM measure used focuses more on face-to-face and interacting modes of collaboration. This focuses attention on the demand-driven approach to KM and on the non-technical issues related to it. This leads to six modes of collaboration being analysed: joint 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. A conservative approach is taken, and only those firms that described at least one of the six measures as highly important for them during 2000 and 2002 are considered KM firms.

In order to estimate the likelihood of a firm using KM between 2000 and 2002, a probit model is specified where the indicator for KM is the dependent variable and the determinants of KM as identified in the literature sections are the independent variables (see Table I).

To test the first hypothesis, information on continuous R&D activities from the questionnaire of the 2003 Mannheim Innovation Panel is used. For *H2*, the concept of consumer-orientation of innovation activities is operationalised by firms' innovation strategies. A dummy variable

**Table I** Construction of the variables

| *Variable Name* | *Type* | *Description* |
|---|---|---|
| Size | Dummies | Size_1 (Reference): 5-49 employees<br>Size_2: 50-99 employees<br>Size_3: 100-249 employees<br>Size_4: 250-499 employees<br>Size_5: 500 + employees |
| Employee fluctuation | Dummy | One, if the growth of employees between 2000 and 2002 was higher than the 75 percent percentile (+13.5 percent) of all firms or lower than the 25 percent percentile of all firms (−7 percent) |
| 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 |

that takes the value one if a firm's strategy is to provide individual solutions for (single) customers is constructed to take this aspect into account in the empirical analysis. *H3* is approached in the model using the industry average (groups of NACE 2 industries – see Table I) for the product life cycle.

For *H4*, another measure of dynamics, the fluctuation of employees, is used, i.e. a dummy variable 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 percent percentile (+38 percent) of all firms or lower than the 10 percent percentile of all firms (−17 percent) in the sample.

Measures of size in terms of staff, industry, belonging to a multinational group are control variables that can be directly derived from questions in the survey. As additional control variable, location in East Germany is added. This variable has not been mentioned in the literature review. It is included in our model since many studies have shown that East German and West German firms differ in their innovation activities and strategies (see, e.g. Rammer *et al.*, 2005; Sofka and Schmidt, 2004). It is also a stratification criterion in addition to size and industry.

### *3.2. Descriptive statistics*

The full set of variables necessary to estimate the empirical model is available for 1,738 firms. Of these, 1,170 firms (67 percent) conduct KM according to the above definition (''KM firms'') and 568 firms (33 percent) do not (''non-KM firms''). The relatively high percentage of KM firms supports the findings from the literature, namely that innovative firms (our sample) tend to implement KM more often than firms without innovation activities. Table II provides descriptive statistics for the independent variables used in the probit regression of KM on the explanatory variables.

The descriptive statistics show that the mean of the KM firms and the mean of the non-KM firms differ. Significant differences can be found in terms of the existence of continuous R&D activities, the share of firms having a customer orientation in their innovation activities, belonging to a multinational group, belonging to a high-tech manufacturing industry and the product life cycle of the industry a firm is from. In terms of firms' size and the share of firms

**Table II** 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 | 0.522 | 0.415 | *** |
| | (0.500) | (0.500) | (0.493) | |
| Continuous R&D activities | 0.612 | 0.693 | 0.447 | *** |
| | (0.487) | (0.461) | (0.498) | |
| Average product life cycle | 9.642 | 9.442 | 10.055 | * |
| | (6.523) | (6.691) | (7.882) | |
| Number of employees | 1,371 | 1,430 | 1,252 | |
| | (10,758) | (10,037) | (12,116) | |
| Employee fluctuation | 0.194 | 0.196 | 0.190 | |
| | (0.395) | (0.397) | (0.393) | |
| Multinational group | 0.252 | 0.278 | 0.199 | *** |
| | (0.434) | (0.448) | (0.399) | |
| East Germany | 0.322 | 0.317 | 0.331 | |
| | (0.467) | (0.466) | (0.471) | |
| Medium-tech manufacturing | 0.334 | 0.343 | 0.317 | |
| | (0.472) | (0.475) | (0.466) | |
| High-tech manufacturing | 0.120 | 0.140 | 0.077 | *** |
| | (0.325) | (0.347) | (0.268) | |
| Knowledge-intensive services | 0.320 | 0.326 | 0.308 | |
| | (0.467) | (0.469) | (0.462) | |

**Notes:** Standard errors in parenthesis; [a] mean difference between firms with KM and firms without KM: *** significant at 1 percent level; ** significant at 5 percent level; * significant at 10 percent level
**Source:** ZEW (2005) (own calculations)

that experience substantial fluctuation of employees and location in East Germany, no differences can be detected between firms with KM and those without KM.

## 4. Results

As expected, a firm's innovation strategy and orientation have a strong impact on the likelihood of it using KM tools (see Table III). Both variables included in the model to capture the nature of firms' innovation activities (continuous research activities and a strong orientation of innovation processes towards customers) are positive and highly significant. Hence, hypotheses one and two cannot be rejected. In an alternative specification a dummy

**Table III** Probit estimation – dependent variable: KM activities between 2000 and 2002

| *Variable* | *Coefficient* | *Marginal effect* | *Robust SEs for coeffi.* | | *Significance* |
|---|---|---|---|---|---|
| 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 | |

**Notes:** *** significant at 1 percent level; ** significant at 5 percent level; * significant at 10 percent level
**Source:** ZEW (2005): Mannheim Innovation Panel, own calculations

variable which takes the value one if a firm has used input from customers for its innovation processes is included in the model. This more general measure of consumer orientation is also highly significant with a coefficient of 0.316 and a marginal effect of 0.119.

Closely related to the innovation behaviour of firms is the product life cycle (*H3*) within 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 it is that a firm will implement KM tools. In accordance with hypothesis a negative coefficient of the product life cycle variable is found; however the coefficient is not significant. Therefore, hypothesis three can be reject.

A surprising result is the insignificant coefficient for the fluctuation of employees. *H4* suggests that firms with higher fluctuation are more likely to use KM techniques. There are two possible explanations for the insignificant estimate: first, the measure of knowledge management used in the analysis focuses on knowledge exchange between departments and employees within the firm. It does not measure the effort firms make 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 personnel. However, this is not their prime purpose. 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 the sample might have influenced the 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, on which the fluctuation dummy variable is based.

In terms of the influence firms' other characteristics have on the likelihood of KM being applied, size is discussed first. Similar to others (e.g. Swan *et al.*, 1999; Earl and Gault, 2003) this study finds that larger firms are more likely to use KM than smaller firms. The empirical model includes four dummies for different categories of firm size. All four dummies are significant, indicating that firms with more than 50 employees are more likely to employ KM than firms with less than 50 employees. A look at the marginal effects on the other dummies shows that it is highest for firms with 500 + employees and 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 indication of a non-linear relationship between size and KM. An estimation of an alternative model not reported on in this paper with the log of the number of employees and the squared term of the log of the number of employees included instead of size dummies also shows that there is a non-linear relationship between size and the likelihood of KM.

There is no empirical evidence that being part of a multinational group has a significant effect. Since size significantly influences the probability of KM being applied, this variable perhaps already captures the impact of being part of a group. Then again, none of the correlation coefficients between the size variables and the multinational dummy are above 0.50 (see Table IV). To check the robustness of the results, an alternative model with a dummy variable for being part of a group is estimated. The level of significance for the size variable does not change. What is more, the estimated coefficients for the size variables are almost identical.

With regard to the influence of the industry in which a firm conducts its main activity, former empirical findings are confirmed (Edler, 2003; Kremp and 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 in is different in some respects. The variable for location of the firm in East Germany is positive but not significant. It is noteworthy in this respect, that the dependent variable only measures the existence of KM, not the intensity or scope of KM. East German firms could be expected to use KM less intensively, but this is left for further research.

**Table IV** 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

## 5. Implications and concluding remarks

In this study the factors determining the use of knowledge management are investigated, using a large-scale survey of innovative German firms. The results show 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, routinised behaviour is present (Coombs and Hull, 1998; Webster, 2004). The search for internal knowledge assets or creativity meetings, which are included in our list of KM tools, seem to become structured and organised 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. This 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, 1996a; Lundvall, 2006; Nonaka *et al.*, 2000).

Focusing on leading-edge users increasingly becomes essential for innovating firms (Rothwell, 1994). The empirical results show that a consumer-oriented innovation strategy that takes this into account, referring to the market pull approach of innovation (Hayes and Abernathy, 1980; Rothwell, 1994), increases the probability of KM tools being deployed on an above-average scale. KM appears to be one way of dealing with the large amount of (sometimes useless) customer input and filtering out the truly valuable suggestions.

Besides these strong findings on innovation activities it can be assumed that the need for KM is also linked to more general firm characteristics. Firms' size and KM are positively related, while employee fluctuation does not seem to be related to KM.

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

Data restriction forces the concept of KM used in this paper to be limited to the collaborative aspects of KM within firms. The focus on collaborative aspects of KM rather than IT-related aspects also helps to lessen the problem that the analysis is based on data from 2000 to 2002. This period comprises the last year of the dot.com bubble and the two years shortly after the bubble burst. Analysing the behaviour of firms with respect to IT might therefore have led to some results which can hardly be generalised. Then again, our broad industry coverage should have mitigated the effects of the dot.com bubble, which mainly hit the IT and closely related industries. It is however necessary to broaden the focus on knowledge transfer, creativity and storage efforts in firms in future studies and to investigate the determinants of and complementarities between all these different groups of KM techniques and aspects. Analysing KM within contexts other than innovation may also be a valuable contribution.

The focus on German firms limits the possibilities to generalise our findings. It needs to be seen whether our results hold for firms in other countries, which may be faced with different economic and cultural framework conditions.

Taking all these results together, this paper emphasises the relevance of the demand-based approach to KM for understanding the innovating firm. Hence, as innovation is the uncertain and spontaneous creation of new knowledge, KM is an important tool to manage innovation activities. KM represents the routinised element of the innovation process. KM activities appear to make 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 greater seems the need to establish appropriate KM measures.

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