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The relationship between knowledge management, innovation and firm performance: evidence from Dutch SMEs

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Abstract:
This article investigates the relationship between knowledge management (KM), innovation and firm performance of smaller firms (less than 100 employees), based on a panel of more than 400 Dutch firms. Regression analyses explain the variations in sales turnover growth from various measures of KM strategies. We distinguish between KM input, throughput and output (or innovation) strategies. We find that KM input strategies related to knowledge acquisition are positively related to sales turnover growth. In contrast, we do not find a relation between KM throughput and KM output (innovation) measures and firm performance. The results emphasize the importance of both knowledge absorption and knowledge creation to the success of innovative efforts in small firms.

Keywords:
knowledge management, growth of small firms, entrepreneurship, innovation, micro data

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1. Introduction

Policy-makers and analysts alike have come to the growing consensus that the future strength of "developed" Western economies depends increasingly upon an effective knowledge-based economy. In the initial decades of the Information and Communication Technology (ICT) revolution (i.e., in the 1970's and 1980's) its major impact was to stimulate entrepreneurship; scale and largeness were no longer required in many sectors to deliver complex products and services (Audretsch, 1995; Van Stel and Carree, 2004). However, in the second wave of ICT development, with its proliferation into less developed economies, entrepreneurs themselves, especially those located in geographic regions with high labour and operating costs, are under pressure to shift production to lower-cost regions and/or to change focus to more knowledge-based activities (Audretsch and Thurik, 2004). Both these related trends, i.e., internationalization of competition, and proliferation of explicit knowledge via ICT innovations, make conscious and top-quality knowledge management (KM) an increasingly critical factor in the competitive performance of both large and small firms.

Perhaps more aptly referred to as knowledge strategy, knowledge management (KM) is a relatively new term that encompasses not only the related notions of knowledge transfer and knowledge sharing (externally from other firms to the small firm and/or internally among firm members), but also the knowledge utilization process (Choo and Bontis, 2002; Takeuchi and Nonaka, 2004). There is relatively little empirical evidence though regarding the actual consequences of KM at the level of the individual firm, especially quantitative studies based on large random samples of small and medium-sized firms or SMEs (Choi and Lee, 2003). The purpose of this article is to investigate the relationship between different KM strategies and firm performance, operationalised as sales turnover growth. More specifically, the goal of the article is twofold: first, to identify whether any aspects of KM (classified into three categories: input, throughput and output) contribute to prediction of sales turnover growth; and second, to determine whether within SMEs, the relationship further varies depending upon the size-class of the firm. We include this second goal because even among SMEs, past research has found size to be an important factor in predicting a wide range of organization characteristics (De Kok, Uhlaner and Thurik, 2006; Geeraerts, 1984) and secondly because rate of growth itself tends to be a function of size (Piergiovanni et al., 2003).

The article is structured as follows. Section two provides additional background about KM as used in this study. Section three presents the framework and rationale for the proposed hypotheses. Section four describes the methods, including data sources, variables, and data analysis. Section five presents the results and Sections six and seven present the discussion and conclusion, respectively.

2. Background

The concepts of KM and innovation as used in this study

This research study builds on the definitions of KM of Takeuchi and Nonaka (2004), Uit Beijerse (2000), Von Krogh et al (2000), Uhlaner and Van Santen (2007) and Blom et al (2006). The conceptualization of KM overlaps to some extent with other literatures, including that of organization learning (Scarbrough and Swan, 2001) and innovation. KM is a relatively new concept, by comparison, but the advantage of using this paradigm is that it provides a means to integrate a number of processes that have been loosely coupled in past research, in particular, by thinking of knowledge as a flow that follows the familiar model of input, throughput and output (Hendrickson and Psarouthakis, 1998).

Although research on KM continues to grow, there appears to be a lack of consensus about the actual components or phases of KM, other than the recognition that it is a process which begins with a flow of information both from outside the organization and from an internal creation process amongst individuals within the firm and also involves some type of throughput and output processes which if successful result in innovative firm behaviors. It is possible however, to identify from different authors, phases which appear to parallel the input-throughput-output paradigm used rather extensively in open systems theory (Hendrickson and Psarouthakis, 1998). Thus, first, in most KM models, there is an acknowledged "acquisition" phase, in which the organization obtains knowledge both internally (for instance, from internal research and development activity) and externally, including, for example, hiring new employees (Holsapple and Jones, 2004), strategic alliances, or going to presentations or seminars (Uit Beijerse, 2000).

A second general category of KM strategies relate to the transformation or throughput phase—for instance, *sharing* knowledge—i.e. disseminating knowledge in the organization and *storing* knowledge—codifying and documenting knowledge (Wong and Aspinwall, 2005, Oshri, 2005) or what Huber (1991) refers to as organizational memory. Data warehousing is one example of a storage practice identified by Von Krogh et al. (2000). Data warehousing refers to a system which holds or stores knowledge, in repositories of books and manuals, KM systems (KMS), ERP and/or other information management systems (both computerized and non-computerized). Not all sharing and storage requires ICT technology or even lends itself to ICT. In particular, non-ICT solutions are thought to be particularly important to share and store *tacit* knowledge, that is, information that is not easily codified and thus cannot be recorded, stored (or transferred) by a written or electronic database (Davenport and Prusak, 1998). Tacit knowledge is typically and perhaps most effectively shared directly between individuals, either through conversation or direct observation. When formalized, it has been referred to as a *knowledge audit* (Von Krogh et al, 2000), that is, discussions among colleagues to share information (especially laterally in the organization) (Davenport, De Long and Beers, 1998).

The third phase of KM has been variously referred to as the application (Blom et al, 2006), enabling (Von Krogh et al, 2000) or emission of knowledge (Holsapple and Jones, 2004). Although theoretically this can be seen as the "output" aspect of KM, in practice, evidence of knowledge applications often look quite similar to innovation, whether as new patents, products or processes. In an extensive qualitative study, Blom and colleagues find that in fact, respondents have a difficult time differentiating between the concept of enabling and innovation output more generally (Blom et al, 2006). For the purpose of this article, thus, the output phase of KM is considered the same as innovation performance, and is evidenced by the number of new processes and products, as well as patents within the organization.

3. Rationale and hypotheses

KM is generally viewed as a process-oriented perspective that reflects strategies to acquire or create knowledge, either externally or internally, secondly, to access, share store or maintain knowledge within the firm, and finally to apply knowledge (Lee and Choi, 2003; Alavi and Leidner, 2001, Sabatier et al, 2005). For the purpose of the present article, we suggest that processes that assist in acquisition of knowledge from outside the organization and creation of knowledge internally be referred to as *KM input strategies*. Strategies that address sharing, codification and storage of knowledge within the firm will be referred to henceforth as *KM throughput strategies*. Although in the literature, an attempt has been made by Von Krogh et al (2000) for instance to identify enabling strategies, in research carried out and reported on by Blom et al (2006), it was found difficult to clearly differentiate enabling strategies from

throughput strategies on the one hand, and innovation performance, on the other. Thus, for the purpose of the present study, rather than try to identify KM output strategies, we consider "outputs" such as rate of innovation (new products, processes and patents) as overlapping the output phase of the KM model. In the present article we will investigate whether various measures of these different KM strategies (i.e. KM input, throughput and output) are related to firm performance of small firms. See Figure 1 for a simplified model. A limited number of control variables are shown in Figure 1 and used in the present research, including company size, company age, sector, and employment growth. The control variables will be discussed in Section 4.

Figure 1 about here

Table 1 lists the items included in the present study to tap these different aspects of KM and knowledge outputs. The list is not meant to be exhaustive but reflects the variety of aspects of KM and innovation portrayed in the model in Figure 1, including elements to tap KM input strategy (external network for knowledge exchange, market research, and cooperation with other firms for renewal), KM throughput strategy (constant renewal as a part of strategy, codification of knowledge, firm-provided training, workers involved in renewal activities, and quality certificate) and finally knowledge output measures, including new products or services, patents, and improvement of internal processes.

Table 1 about here

3.1 The relationship between KM input strategies and firm performance

In her seminal work, and referred to as the resource-based view, Penrose (1995) argues that it is the ability to create knowledge that helps to explain the firm's ability to grow. Although in theory, companies may acquire knowledge both internally and externally, past research on SMEs reveals that the greater part of knowledge that SMEs acquire comes from outside the firm: from suppliers, colleagues and competitors, as well as clients. The knowledge infrastructure within the firm is used to only a very minor degree for acquiring knowledge (Kerste and Muizer, 2002, Prince and Becht, 1999). Cohen and Levinthal (1990) suggest that external knowledge in particular increases the absorption capacity of a firm by forcing a reconfiguration of existing knowledge. Nevis et al. (1995) suggest that learning is greater when more assorted interpretations are developed by the organization. Strategic alliances are one way to bring more information into the organization (Cegarra-Navarro, 2005). Cegarra-Navarro (2005) concludes such alliances stimulate organizational learning. Such learning is found to be associated, in turn with better firm performance in recent research by Spicer and Sadler-Smith (2006).

Caloghirou et al (2004) in their empirical research, find a link between strategic alliances, and reading science and business journals, in particular, and the extent of innovation, but do not test for direct links with sales growth. Resources such as the ratio of R&D employees to total employees are also linked to sales growth from new products in their study. Desouza and

Awazu (2006), in a qualitative study, identify strategies followed by SMEs in particular. They support a claim by Robinson (1982) that SMEs have a knack for exploiting foreign (i.e. external) sources of knowledge, and that larger organizations are less apt to exploit these same sources (Prahalad and Ramaswamy, 2004). In a study of the effects of technology co-operation with outsiders (e.g. industry, laboratories, universities, strategic alliances), Sher and Yang (2005) find that sector has an important moderating effect. Thus, cooperation is positively associated with return on assets for IC design firms only. This also holds for the effects of research and development intensity (that is, the ratio of R&D experience to the total number of employees). The overall amount of quantitative empirical research linking knowledge acquisition or KM input strategies and firm performance is fairly limited, and is hampered by lack of consistent controls for sector or size differences, small sample sizes, and different operationalizations for both the independent and dependent variables. Nevertheless, the theory on absorptive capacity, and link with the resource-based view lead us to propose the following first hypothesis:

Hypothesis 1: SMEs which rely upon KM strategies to acquire knowledge for the firm, so-called "KM Input" strategies," are likely to grow more quickly than those firms not using such strategies.

3.2 The relationship between KM throughput strategies and firm performance

A second set of KM strategies refer to the distribution and modification of knowledge within the firm, including sharing, codification (from tacit to explicit), and storage. These strategies include a combination of ICT and non-ICT approaches. Research regarding the benefits of such strategies is less clear. There is limited research on testing the relationship between KM strategies and financial performance, even less on research specifically involving sales growth. However, drawing from organizational learning theory, the assumption has often been made that effective acquisition and utilization of new knowledge is a source of flexibility, adaptability and competitive advantage (Stata, 1989, Spicer and Sadler-Smith, 2006), and hence associated with better organizational performance. Though labeling their variable organization learning, Spicer and Sadler-Smith (2006) examine the influence of a learning orientation and sales growth, finding some(weak) support for the relationship between the two variables, especially the degree to which information is shared with employees as well as worker involvement in renewal activities (which is similar, to some extent to the organizational learning concept).

The findings of Spicer and Sadler-Smith (2006) aside, other authors are fairly equivocal about the expected positive effects of KM throughput strategies. For instance, Shin (2004) points out that sharing of knowledge involves not only benefits but also costs. Implementing many types of KM infrastructures requires a substantial financial and nonfinancial investment (Shin, 2004). Formal mechanisms are also insufficient to transfer tacit knowledge (Makhija and Ganesh, 1997; Cegarra-Navarro, 2005), which may embody more of the unique capabilities of the firm. Desouza and Awazu (2006) also question, especially for SMEs, the importance of formal techniques for sharing information. In their qualitative study, they find that SMEs typically have deep levels of common knowledge. Each employee has a very similar foundation and grounding in organizational matters. Perhaps given the smallness of size, such information is easily transferred. In short, sharing, codification and storage strategies may be less important in SMEs because basic knowledge is often quickly shared. Nevertheless, since in the process models of KM, throughput strategies involving sharing, codification and stor-

age are frequently mentioned as part of the overall KM model, and thus perhaps also key to the absorption capacity of the firm, we posit the second hypothesis as follows:

Hypothesis 2: SMEs which rely upon KM strategies to distribute knowledge for the firm (through sharing, codification and storage), or so-called "KM Throughput" strategies," are likely to grow more quickly than those firms not using such strategies.

3.3 The relationship between KM output (innovation performance) and firm performance

The final set of variables reflects the extent to which the SME is able to apply new knowledge—i.e. the rate of innovation within the firm. This can be viewed either as knowledge output, or in the context of the innovation literature, as innovation performance. Although some authors have attempted to identify "enabling strategies" separate from the knowledge input and throughput strategies described above, in practice, it has been rather difficult to separate the two (Blom et al, 2006). For the present study, we thus adopt the approach of identifying elements of innovation performance (that is, patents, improvements in process or new products), as evidence of a successful knowledge output strategy, henceforth, to be referred to as "knowledge outputs".

Research linking innovation and performance is inconsistent (Freel, 2000). A variety of studies have examined the link between new product innovation and sales growth. Some research supports the claim that innovation is positively associated with rapid growth within small firms (Storey, 1994; Geroski and Machin, 1993; Roper, 1997; Wynarczyk and Thwaites, 1997; Moore, 1995). Heunks (1998) examines the link between changes in production marketing and research and development and growth in sales, finding a significant positive relationship for SMEs between 10 and 50 full time equivalents (fte) but not for those between 51 and 200 fte. In more recent research, Hall and Bagchi-Sen (2002) find a positive relationship between new product introduction and redesigned products and total revenue growth, but only within the biotechnology sector. Some of the inconsistencies in past research can be explained by comparing innovators and non-innovators in different sales turnover growth categories. In particular, Freel (2000) finds a nonlinear relationship such that non-innovators are more prevalent in declining, stable and (low to average) growth categories, but that innovators exceed non-innovators in the "super-growth" category, that is, firms that are in the highest quartile with respect to sales turnover growth.

Regarding the use of patents, past research is also somewhat inconclusive due to mixed findings. Arundel (2001) points out for instance that patents are seen as less valuable than secrecy in protecting new innovations. The trend is even stronger among small firms. Arundel (2001) concludes that patents are relatively unimportant as appropriation methods in many sectors. Calantone et al (1995) find a positive correlation between several innovation performance variables including new product development, product improvement and new product introductions, and return on sales growth. However, they address a small sample (n=65) in one industry (office and residential furniture) and with companies with at least $10 million in sales. Further, they don't control for size or employment growth. Caloghirou et al (2004) also examine the effects of innovation on growth but their sample includes firms with up to 1250 employees, well beyond any definition of SMEs. Finally, in a rather carefully conducted study, Ernst (2001) finds that patents are positively related to sales increases given a two to three year time lag. However, again, their sample is small (n=50) and restricted to a fairly technical sector (machine tool manufacturing). Hall and Bagchi-Sen (2002) examine the relationship between patents and total revenue growth for biotechnology firms but they find no statistically significant relationship. On balance, it is difficult to draw clear conclu-

sions from the extant research on knowledge outputs due to the lack of consistent controls for sector and size, and due to wide variation in definition and measurement of firm performance. Nevertheless, some research does point to the conclusion that innovation matters. Thus, we state hypothesis 3 as follows:

Hypothesis 3: SMEs which report knowledge output, via various innovation indicators, are likely to grow more quickly than those firms who do not report such output.

3.4 Size as an important control variable

The resource-based view (Penrose, 1995) argues that when a firm grows in size, it will reorganize its resources to take advantage of more obvious opportunities for specialization. Specific to KM, the firm's size as measured by number of full time employees is also positively correlated with the collection of information (Mohan-Neill, 1995). Even for a relatively small sample, Uhlaner and van Santen (2007) find evidence for a positive relationship between size and formalized KM practices. However, in the extant literature on innovation, some contradictory results are found for several hypothesized effects. In particular, some of the size effects may only start to work for larger firms. Previous studies have also shown non-linear size effects (e.g. Cohen and Levinthal, 1989, Lööf and Heshmati, 2006).

The relationship between size and company growth is also controversial and dates back to Schumpeter (1942). Some findings would suggest that innovation tends to grow at a rate less than proportional to firm size. That is, as a firm increases in size, it grows at an ever decreasing rate (Stock et al, 2002). Stock et al. (2002) find a negative relationship between size and dynamic innovation performance, i.e. the rate of change of new product technology performance. Furthermore, a range of earlier studies point at the size dependence of determinants of firm performance, particularly in relation to strategic renewal and innovation efforts (e.g. Kemp et al, 2003 and Cohen and Levinthal, 1989). Therefore, it is important to control for size effects when exploring the relationship between various aspects of KM and firm performance.

4. Method

4.1 Data source and sample

The data for this article are drawn from telephone interviews with the Dutch SME policy panel, a longitudinal panel of firms with less than 100 employees, collected over a period of several years by EIM, a Dutch research firm. In particular for this project, the research team started with a selection of 606 firms from the panel that participated during the years 1999, 2000, and 2002. In this paper we use average annual growth rates of sales turnover and employment over the period 2000-2002. Observations with extreme values were removed, that

is, annual growth rates of more than 100% or less than minus 50%.[1] The average annual growth rates over the years 2000-2002 are computed *after* removal of the extreme values. Using the resulting sample of firms with non-extreme growth rates, we ran an auxiliary regression with all 11 KM variables from Table 1 and the control variables mentioned in Section 3. A high value of the Jarque-Bera test statistic was obtained suggesting a skewed distribution of the original residuals from this regression. Thus, a final estimation sample was created by eliminating the outliers -- in particular, those observations with an (absolute) standardized residual exceeding 2.5. Applying this procedure resulted in 421 firms to be included in the estimation sample.

Table 2 presents the distributions of the 421 firms by sector and size. The observations are quite evenly spread over the different sectors and size-classes. Also, though not presented here, outliers tended to occur fairly evenly across sectors. With respect to size, three size-classes are identified: micro (0-9 employees), small (10-49 employees), and medium-sized (50-99 employees).

Table 2 about here

4.2 Variables

The following variables were measured for this study: KM strategies, innovation performance, sales turnover growth, company-size, sector, firm age, and employment growth.

KM (input and throughput) strategies and knowledge output measures

KM strategy and knowledge output items collected in 1999, 2000 and 2002 form the main source of data for this set of variables. The KM variables are averaged over the years 1999, 2000 and 2002 (2001 is missing). The corresponding survey questions are listed in Table 1 and are all binary (with yes/no responses possible). Although the items were originally referred to in early studies as the "Innovation Barometer" (De Jong, 2000), they also fit the more recent paradigms for KM, as described in the introduction. In particular, it is possible to cluster the practices according to KM input strategies, i.e. strategies to capture and acquire knowledge (including the items: external network for knowledge exchange, market research, and cooperation with other firms for renewal); KM throughput strategies to share, codify and store knowledge (including the items: constant renewal as a part of strategy, codification of knowledge, firm-provided training, workers involved in renewal activities, and quality certificate), and knowledge outputs or innovation performance (e.g. new products or new services, patents, and improvement of internal processes).

[1] Using relative change measures favours the very small firms since these must grow faster in order to reach the minimum efficient scale in their industry (Almus, 2002). For instance, for micro-firms, an increase from 1 to 3 workers corresponds to a change of 200%. We feel that our model is not appropriate for inclusion of such extreme growth percentages, as the distribution of the variables would be too skewed. By excluding the extreme values we basically remove those firms that grow from one to two or three persons in a certain year. Our approach is justified as it is not our intention to identify the fast-growing firms (for instance by means of a probit estimation on the top 10% of a certain distribution of firm growth rates, see Almus, 2002) but to identify determinants of the (sales turnover) growth rate that are valid for fast-growing firms as well as non-fast-growing firms. Any bias towards small firms that may still exist after removal of extreme values is corrected for by including size-class dummies in our model.

The dependent variable: average annual sales turnover growth 2000-2002

Sales turnover growth is based on a three-year annual average from 2000 to 2002, based on self-reports by respondents to the following question: "Could you provide an indication of sales turnover –excluding VAT– of your company in the previous year?". Average annual sales turnover growth is expressed in percentage changes.

Control variables

To obtain unbiased estimators for the effects of the KM variables, a number of control variables are also included in our regression model: (i) dummy variables for sectors, (ii) dummy variables for size-classes, (iii) firm age and (iv) average employment growth. The eight sectors and three size-classes corresponding to our dummy variables are listed in Table 2. Size-class dummies are included to allow for structural growth differences between firms of different size-classes. Even though observations with exceptionally high growth rates from the sample were removed in the estimation sample (which are mostly smaller firms), it is still possible that Gibrat's Law (Piergiovanni et al., 2003)—that is, that all firms grow at the same rate, independent of size— is violated in our estimation sample. Typically, small firms grow at systematically higher rates than their larger counterparts.Thus, size-class dummies are also included in the model. Literature on the effect of firm age on firm performance indicates that young firms grow faster than old firms (Verhoeven, 2004). Therefore, the model also controls for age. Finally, as employment is an important factor of production, we use average annual employment growth over the period 2000-2002 as an explanatory variable for sales turnover growth.

4.3 Data analysis

To measure the structural impact of KM on economic performance at the firm-level, which smooth yearly variations, a cross-sectional regression analysis is used where both the dependent and independent variables are averaged over time. More specifically, regressions are calculated explaining sales turnover growth of small firms from the KM and innovation variables included in Table 1. As explained in Section 3.4 the relationships may vary by size-class. Size-class differences in the relationships are explored by allowing intercepts and the other estimates to vary for each size-class. In particular, all KM strategy and knowledge output measures are multiplied by the three size-class dummies (micro, small, and medium-sized).

Given suspected multicollinearity due to relatively high intercorrelations among the various items (up to r = .5), an approach needed to be chosen to decide which variables to include in the model. To avoid excluding variables prematurely, liberal criteria were used for inclusion of variables. The selection procedure is as follows: eleven regressions were first run to predict average sales turnover growth from one of the eleven KM strategy and knowledge output measures. The control variables are included in each of these eleven regressions. In a second step, only KM and/or innovation variables were (simultaneously) included for which at least one size-class coefficient was significant at the 5% level in step 1. Finally, given the specification resulting from step 2, we included each of the non-selected KM variables once more, one at a time in separate regressions, to see whether the interplay with the selected variables results in significant estimates, despite their non-significance in the first step.

This approach was followed to identify variables to include in the final model specification, while keeping the extent of overestimation of standard errors due to multicollinearity to a minimum.

5. Results

This section presents results of the data analysis. The first subsection presents the descriptive statistics, including means and standard deviations. The second subsection presents results for the multiple regressions predicting sales turnover growth.

5.1 Descriptive statistics

Means and standard deviations of the variables in the data set are reported in Table 3. These statistics are based on the estimation sample and thus exclude outlier observations as explained earlier. From the first row of Table 3 we see that, on average for our sample period, the firms in our data set have achieved a small positive sales turnover growth (6.7%). Smaller firms perform slightly better than their larger counterparts. The differences between size-classes are not significant though: the large standard deviations further point at a large amount of variation in growth levels among the firms in the panel.

We also see that about half (51%) of the firms claim to have introduced new products or services in the past three years. The percentage of firms possessing patents is small: only eight (8) percent of the total sample. Some further interesting information from the table is that about half of the firms use an external network to exchange knowledge and three out of four firms provide some form of training to employees. Most KM measures score higher in the subsamples of small and medium-sized firms than for micro firms.

TABLE 3 ABOUT HERE

5.2 The impact of KM strategies on sales turnover growth

Multiple regression results for sales turnover growth are shown in Table 4. Models I-III present those regressions where the listed KM strategy and knowledge output items have a significant coefficient for at least one size-class when controlling for employment growth, the log of firm age, sector and size-class dummies (step 1 of the variable selection procedure described in Section 4.3). The only KM strategy or output items with a statistically significant effect for at least one size-class, of the 11 items tested, include the following: external network for knowledge exchange, market research, and cooperation with other firms for renewal. What is interesting is that all three of these items relate to the input or acquisition stage of KM. In addition, the item “workers involved in renewal activities”, though having no significant effect in Model IV, includes a significant negative effect (for micro firms only), in the combined model, shown in Column V.

TABLE 4 ABOUT HERE

5.3 Size-class effects and the impact of the control variables

We find a number of size-class effects in the sense that coefficients for certain variables are significantly different for different size-classes. A size-class effect is evident first of all for the variable external network for knowledge exchange. Thus, the effect on sales turnover growth appears greater (and more significant) for the micro and small firms compared to the medium-sized firms. For market research the effect is greatest for the smallest (micro) firms. An opposite trend is found for 'cooperation with other firms for renewal', with the most significant coefficient for medium-sized firms. We also find a size-class effect for 'workers involvement in renewal activities', with the strongest negative effect for micro firms.[2]

Regarding control variables and their effects, firm age contributes negatively to sales turnover growth, even when controlling for company size. Employment growth has a positive significant effect on sales turnover growth. These results are as we expected.

6. Discussion

6.1 Discussion of results

The most notable pattern of results is that all three of the items classified as KM strategy input variables are significant whereas the KM throughput strategy and knowledge output items are not significant.

The use of an external network has a significant positive effect on turnover growth for small firms. This network may include universities, competitors, partners, suppliers and advisors. Firms that make use of such networks are able to exchange knowledge on the product level, but also information on market structure, trends and developments could be shared. This raises the level of innovation input (information being one of the inputs). Furthermore, the knowledge diffusion accelerates the transition process of strategic inputs into actual output (Sher and Yang, 2005).

The effect of conducting market research is also positive—most consistently for micro firms. Market research is an important tool for SMEs to explore consumer wants and to take these into account in product development. First, from a consumer perspective, market research can be used to collect consumer preferences with respect to products and services. (Lifestyle) trends may be identified. From this perspective, market research is used as a means to create new information that the firm can use to develop innovations (i.e., new or improved products). Second, from a producer perspective, a firm can use market research to investigate the possible demand for a newly or improved product or service. This gives direction to the market introduction and/or promotion and distribution strategy towards the relevant targeted

[2] Probably, the investments required for renewal activity imply lower sales in the short run. The negative effect is smaller for the larger (and often older) firms though, suggesting that in the longer run renewal activities may pay off. Indeed, investments in renewal activity at the micro stage might actually be a requirement to survive and to reach the minimum efficient scale in the industry (Almus, 2002).

groups. The variable does not distinguish between these different perspectives, but altogether market research contributes to a higher sales turnover growth.

Oddly, cooperation with other firms for renewal is associated positively with turnover growth for the "medium sized" class of firms in this study, but not for the micro or small firms. Perhaps the word, "renewal" itself suggests that the firm is already established.

6.2. Limitations and directions for future research

Further research is particularly useful in four directions. *First of all*, based on this study we expected all phases of the process of KM (input strategies, throughput strategies and knowledge output) to be of critical importance to small business performance. The particular organization of such efforts has received relatively little attention, particularly for small and networked firms. But our findings raise questions of whether the identified strategies function sequentially in a process flow. If that were the case, one would expect progressively stronger links between firm performance and knowledge input strategies, knowledge throughput strategies and knowledge output, but just the opposite was found. One explanation is that perhaps the type of knowledge that is gained with the input strategies is not linked with innovations per se, but with other critical information that provides a stronger competitive advantage for the SME. For instance, by linking with external networks, the SME may reduce transaction costs for information acquired to run the firm, but not necessarily to develop new knowledge. In a recent study, Bryan (2006) reports on the differences between in-house training and ex-house management training. Only the latter is associated with a long term growth in sales. This may reflect the difference in knowledge acquisition vs. knowledge sharing within the firm (the former, consistent with our results, being more strongly linked with sales turnover growth). Future research on training and development programs may need to make clearer distinctions thus with the knowledge consequences of such programs (is it used primarily to redistribute existing knowledge already within the firm or to acquire new input from the outside).[3] Consistent with ideas on absorptive capacity, proposed by Cohen and Levinthal (1990), it may be that the latter has more direct positive consequences for firm performance.

Second, the complexity and structure of the internal and external environment for innovation have not been included in the analysis here. Including measures of the centrality and proximity of particular partners could improve our insight of optimal timing and effective organization of strategic renewal for small businesses.

Third, the measurement of the different KM items lack detail, since they are based on simple checklist questions. To which extent are our results affected by the fact that the KM strategy and knowledge output indicators are binary instead of continuous? Although this appears to work for some items, in the case of quality certificates for instance, past research by Prajogo and Sohal (2004) suggest that more detail may be required. In their study, which examines the presence of total quality management (TQM) they find it is not so much the presence of TQM but whether the subactivities being adopted for TQM are more mechanistic or organic which determines the relationship between a strategy and firm performance. In short, their findings suggest that it may be too simplistic, for instance to determine if a quality program is in place but to explore in greater detail the type of quality program that has been introduced. In future research, it might be helpful to develop more detailed questions to measure the other types of KM strategies as well.

[3] De Kok (2002) points at the important role of training *support* for the effectivity of training.

Fourth, continuity of data collection on KM and performance measures will enable us to further deepen our understanding of business performance in the long run (Freel and Robson, 2004). In this respect the short time period and sample selection used in this study might be considered a limitation. The generalizability of our findings should be tested for with respect to a trio of aspects. First, although an effort was made to overcome one shortcoming of cross-sectional research by combining data from different time periods, further research needs to examine whether results remain valid over a longer period of time. Second, are our results also valid for other countries than the Netherlands? Third, are our results also valid for firms with more than 100 employees? Again, further data collection is crucial for these questions to be answered.

7. Conclusions and practical implications

In this paper, we investigate the relationship between KM, innovation and firm performance for SMEs, allowing for variations in effects in three size-classes—micro (0-9 employees), small (10-49 employees) and medium (50-99 employees). We examine the relationship between a range of specific KM input and throughput strategies, certain knowledge outputs and sales turnover growth, controlled for firm age, firm size, employment growth and sector.

Our estimation results suggest that KM acquisition or input strategies may be the most important aspect of the innovation process influencing the performance of small firms. Market research and the use of external networks for knowledge exchange are associated with higher sales turnover growth. In addition, we find a positive effect of cooperation with other firms for renewal, at least among the medium-sized firms.

On the other hand, throughput aspects of KM, including codification of knowledge, firm-provided training and quality certificates are not found to have a positive effect in the current study. Nor are certain output aspects of KM and innovation, including new products or new services, patents and improvement of internal processes. Of course these results do not necessarily mean that throughput or output aspects of KM are irrelevant for sales turnover growth. However, in the present study, we conclude that the KM input strategies are clearly better predictors of sales turnover growth.

Based on our results, policy makers interested in stimulating firm growth can best do so by encouraging knowledge diffusion to SMEs from other organizations and amongst SMEs themselves. Firms should be encouraged to participate in networks (universities, competitors, suppliers, advisors) and to cooperate with each other. For small firms in particular, the knowledge exchange is critical in the success of KM innovation efforts. It should be a point of attention to entrepreneurs. Small firms often lack the financial capacity to make full use of new methods and innovations developed by academic researchers. Likewise, universities have little incentive to share their (newly created) knowledge with small firms. In this respect, the Dutch Ministry of Economic Affairs experimented with so-called 'knowledge vouchers' for SMEs in 2004 and 2005. Small firms can exchange these vouchers at universities to outsource (parts of) projects. In turn, universities cash the vouchers after delivering knowledge to the small firm. In this way, both small firms and universities are given additional incentives to cooperate with each other. The success of the 'knowledge vouchers' experiment (6000 vouchers in 2006) has resulted in official (statutory) regulation in the Netherlands.

It may also be worthwhile to encourage university researchers to temporarily work at small innovative firms, so that employees and entrepreneurs can benefit from academic knowledge and integrate this knowledge in the business process (and to make future academic work more practice-oriented). It should be noted that there is more to effective KM and innovation

than just sitting in at “innovation meetings” or visiting a university professor once in a while. The entrepreneurial spirit should be real for any such measures to be effective, as was true for earlier efforts in supporting the development of innovative regions and clusters around specific universities (Wever and Stam, 1999).

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Figure 1: A simplified model of knowledge management, innovation and firm performance

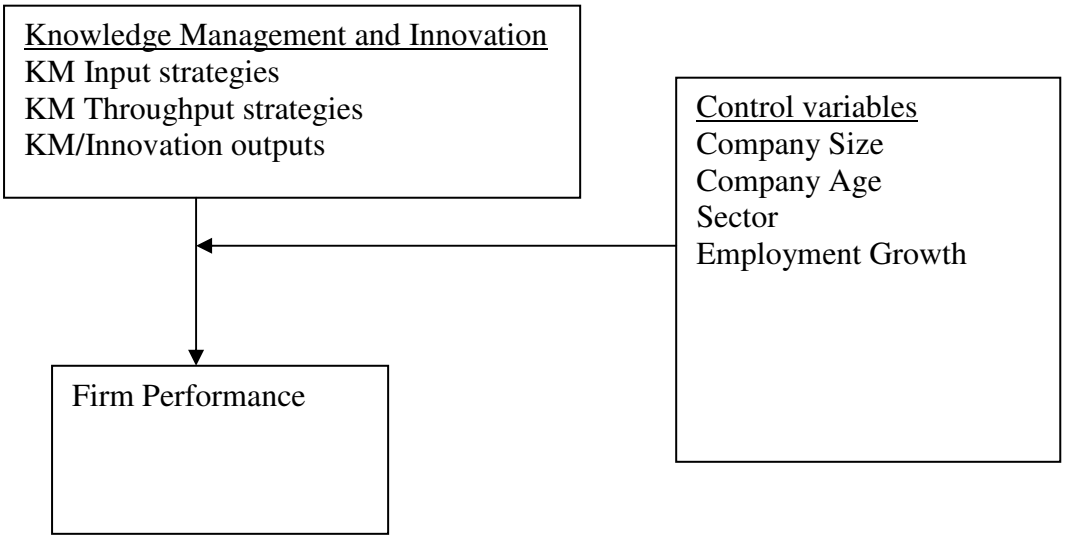

Table 1 Variable labels and survey questions

	Label	Question
Knowledge management (KM) Input strategies		
1	External network for knowledge exchange [4]	Does your company use an external network for the exchange of knowledge, for instance through universities, competitors, suppliers or advisers?
2	Market research	Did your company perform (or outsource) market research over the past three years?
3	Cooperation with other firms for renewal	Does your company cooperate with other companies or institutions to carry out renewal projects?
Knowledge Management (KM) Throughput strategies		
4	Constant renewal part of strategy	Does constant renewal form part of your company strategy?
5	Codification of knowledge	If yes (on question 4), are these renewal efforts written down on paper?
6	Firm-provided training	Did your company in the past year finance any additional training of employees (including unpaid family workers and owner/managers)?
7	Workers involved in renewal activities	Are your employees (including unpaid family workers and owner/managers) involved in renewal activities?
8	Quality certificate	Is your company in the possession of a formal quality certificate (for instance, ISO)?
Knowledge output (output of the KM process)		
9	New products or services	Did your company put new products or services on the market over the past three years?
10	Patents	Is your company in the possession of patents?
11	Improvement of internal processes	Did your company introduce improvements or renewal in internal company processes over the past three years?

[4] We avoid using the word 'cluster' in our label, as that would imply a geographical concentration not referred to in the question. Wever and Stam (1999) show that for Dutch high technology SMEs (some 8% of all SMEs), 'regional clusters, characterized by innovation linkages with other firms and knowledge centres, hardly exist'. Instead, they find that most of the customers and suppliers which the interviewed high technology SMEs consider relevant for their innovative development are located outside their own (COROP or NUTS3 level) region.

Table 2 Distribution of firms over sectors and size-classes

Sector	Observations	Share in total
Manufacturing	70	0.166
Construction	79	0.188
Trade	75	0.178
Hotels and restaurants	43	0.102
Transport and communication	45	0.107
Business services	49	0.116
Financial services	35	0.083
Personal services	25	0.059
Total	421	1.000

Size-class	Observations	Share in total
Micro firms (0-9 employees)	170	0.404
Small firms (10-49 employees)	156	0.371
Medium-sized firms (50-99 employees)	95	0.226
Total	421	1.000

Table 3 Descriptive statistics

		Total	Micro (0-9)	Small (10-49)	Medium-sized (50-99)
Average annual sales turnover growth (%)	Mean	6.7	7.7	6.7	5.0
	(Std. dev.)	(12.7)	(13.7)	(12.9)	(10.1)
New products or services	Mean	.51	.40	.57	.60
	(Std. dev.)	(.40)	(.38)	(.40)	(.39)
Patents	Mean	.083	.037	.094	.15
	(Std. dev.)	(.24)	(.17)	(.26)	(.31)
Improvement of internal processes	Mean	.78	.66	.84	.89
	(Std. dev.)	(.32)	(.37)	(.28)	(.22)
Constant renewal part of strategy	Mean	.68	.57	.73	.79
	(Std. dev.)	(.36)	(.39)	(.35)	(.29)
Codification of knowledge*	Mean	.41	.24	.47	.60
	(Std. dev.)	(.40)	(.33)	(.42)	(.37)
External network for knowledge exchange	Mean	.51	.42	.54	.64
	(Std. dev.)	(.38)	(.38)	(.37)	(.37)
Market research	Mean	.35	.19	.42	.49
	(Std. dev.)	(.39)	(.30)	(.40)	(.43)
Cooperation with other firms for renewal	Mean	.44	.33	.44	.65
	(Std. dev.)	(.38)	(.35)	(.37)	(.35)
Workers involved in renewal activities	Mean	.69	.55	.76	.85
	(Std. dev.)	(.35)	(.38)	(.30)	(.26)
Firm-provided training	Mean	.71	.50	.81	.92
	(Std. dev.)	(.38)	(.42)	(.29)	(.20)
Quality certificate	Mean	.34	.20	.32	.62
	(Std. dev.)	(.42)	(.34)	(.41)	(.45)
Observations		421	170	156	95

* Percentage refers to whole sample (i.e., including those firms answering ‘no’ on question 4 of Innovation Barometer, see Table 1).

Table 4 Regressions explaining average annual sales turnover growth 2000-2002

		I	II	III	IV	V
Constant		15.3 ***	15.2 ***	15.9 ***	17.8 ***	15.8 ***
External network for knowledge exchange	micro	5.6 **				5.1 *
	small	4.8 *				5.6 *
	med.	3.8				0.1
Market research	micro		9.5 ***			10.3 ***
	small		2.1			1.6
	med.		4.9 *			3.4
Cooperation with other firms for renewal	micro			4.2		2.8
	small			1.1		-0.3
	med.			6.9 ***		5.9 **
Workers involved in renewal activities	micro				-0.3	-6.1 **
	small				-0.9	-4.0
	med.				1.2	-2.8
Log (firm age)		-4.1 ***	-3.9 ***	-4.2 ***	-4.1 ***	-3.9 ***
Employment growth		0.38 ***	0.38 ***	0.40 ***	0.40 ***	0.37 ***
R^2		0.215	0.222	0.208	0.196	0.249
N		421	421	421	421	421

Coefficients for sector and size-class dummies not reported.
*; **; ***: Significant at 10%, 5% or 1% level, respectively.
Significance levels are based on heteroskedasticity-consistent standard errors.
All remaining Innovation Barometer variables were not significant at 5% level (for all three size-classes) when included separately (but including all other controls).

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