The relative effect of utilizing knowledge from competitors on the newness of innovations

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Abstract

It seems likely, that using one's competitors as external knowledge sources will lead to different organizational outcomes as compared to other types of external knowledge sources. However, most existing studies that examine the role of external knowledge flows on the innovative performance of firms do not make a systematic distinction between different types of knowledge sources or focus on one type of source in isolation. Therefore, little is known about the relative effect of acquiring external knowledge from competitors.

The goal of the research presented in this paper is to shed some light on this issue. More specifically, it answers the following research question: *What is the relative effect of using knowledge flows from competitors on the newness of innovations?*

In order to answer the research question, the South African Innovation Survey 2001 database has been used. The findings indicate that there are indeed significant differences between the effects of the use of different types of knowledge sources. Acquiring knowledge from competitors is positively associated with the propensity of firms to innovate, but not with the percentage of sales obtained from innovative products. Moreover, the results indicate that the newer the innovation, the smaller the importance of external knowledge and the larger the effect of internal sources of knowledge, such as R&D.

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1. Introduction

From a theoretical point of view, competition and knowledge exchange are often seen as two mutually exclusive phenomena (e.g. Van de Ven & Walker, 1984). Firms are often assumed to try to prevent competitors from getting access to their knowledge, product specifications, or production processes in order to prevent imitation. However, empirical evidence indicates that this is not necessarily the case. Firms often do acquire knowledge from competitors (e.g. von Hippel, 1987; Levy et al., 2003). It seems likely, however, that different types of knowledge are obtained from competitors as compared to the knowledge obtained from other types of partners, because the dangers of, for example, knowledge spillovers, appropriation concerns, and imitation are more severe. As a result, the effect of utilizing knowledge from competitors is likely to lead to different organizational outcomes as compared to the utilization of other types of external knowledge sources.

However, most existing studies that examine the effect of using external knowledge sources on the innovative performance of firms do not make a distinction between different types of knowledge sources, but treat (the effects of) all external sources of knowledge as identical (e.g. Ahuja, 2000). Studies that do look at specific sources of knowledge usually only focus at a single type of source, such as users (e.g. Lundvall, 1988), suppliers (e.g. Batenburg & Rutten, 2003), or universities (e.g. Audretsch et al., 2004). The goal of the research presented in this paper is to shed some light on the relative effects of using knowledge from one's competitors on the innovative performance of firms, as compared to other (external) sources of knowledge. Specific attention will be paid to the level of newness of the generated innovations. Based on the above, the following research question is posed: *What is the relative effect of using knowledge flows from competitors on the newness of innovations?*

In order to answer this research question, a theoretical discussion concerning the role of different types of external knowledge sources will be given first. However, due to the fact that there is little literature dealing with the relationship between the use of different types of knowledge sources (and competitors in particular) and the innovative outcomes of firms, an exploratory approach has been adopted for the empirical part of the paper. Subsequently, the database that has been used for this research will be introduced, and its strong and weak points will be discussed. Next, the methodology employed in this research, a Tobit II analysis, is discussed, followed by the presentation of the results of this analysis. Finally, the results will be discussed and several conclusions will be drawn.

2. External knowledge sources and innovation

The importance of external sources of knowledge for organizational performance, and innovative performance more in particular, has become more and more profound over time (Owen-Smith & Powell, 2004). By and large, the notion that no firm may function as an island on itself, but needs resources and knowledge resources possessed or controlled by other (external) actors, such as clients, suppliers, competitors, stakeholders, central and local public administration actors, and consultants, has been widely accepted (Freel, 2003). Through these external sources a firm can get access to resources and knowledge that are not available within its own boundaries, which can lead to both financial and innovative advantages for the firm in question. The main argument behind this relationship is a resource deficit mechanism, which forces innovating firms to tap into external knowledge sources to produce innovations. This relationship has been substantiated empirically in numerous studies (see for an overview: Pittaway et al., 2004).

Firms can use knowledge from different types of sources, such as buyers, suppliers, universities, electronic databases, patents, competitors, and so on. These actors possess different types of knowledge. For example, universities generally possess scientific and fundamental knowledge, whereas consultants are likely to possess more practical and directly applicable knowledge. It seems likely that tapping into these different types of knowledge will also yield different outcomes in terms of a firm's innovating performance. Whereas the knowledge from a university contains much new information or knowledge, it might be very hard to apply, leading to few, but very new innovations when this knowledge is successfully utilized. On the other hand, the knowledge that can be obtained through electronic databases is heavily standardized and codified, contains little new information, but is very easy to apply, probably leading to incremental innovations when the knowledge is successfully utilized by the firm.

In this sense, using one's competitors as an external knowledge source is an interesting phenomenon because, as has been stated earlier, the risks of spillovers and imitation are substantial. Therefore, it seems unlikely that competitors are willing to share very new and crucial knowledge with each other. Levy et al. (2003), for example, conclude from a game-theoretic approach, that knowledge exchange between competitors is only likely to happen in situations where the synergy benefits of knowledge exchange are high, and the potential of the partner to increase the future value of the exchanged knowledge beyond the initial exchange (called leverage) is low. This is the case as the "negative reversed impact" of exchanging resources with competitors is large, due to the fact that these resources can be used by the competitor and thereby lowering the value for its original owner. Even though this effect can occur in every situation in which knowledge is transferred, its impact is especially relevant in the case of competitors. Based on their analysis, Levy et al. (2003) conclude that only in specific cases, like co-operative design, knowledge exchange between competitors is likely to occur. As a result, the outcomes of these exchanges, in terms of innovative performance, are likely to be different from the outcomes of knowledge exchange with different types of partners as well.

2.1 Innovation outcomes

This paper deals with the impact of the use of different knowledge sources on innovation performance. However, a firm's innovation outcomes are a multi-dimensional concept that needs, for the purposes of this paper, some elaboration.

Many studies on innovative activities of organizations take R&D and patents as relevant indicators of the outcomes of innovation. However, both indicators have deficiencies. In the case of R&D, at least four disadvantages are often mentioned in literature. Firstly, R&D is an input and not an output of the innovation process. Since inputs can be used more or less efficiently, high R&D levels do not necessarily create high levels of innovative output.

Secondly, R&D is just one among several indicators to measure input. Examples of these are investments in outsourced research, licenses and training. Thirdly, it is often unclear what R&D exactly indicates. Is it basic research (far from market applications), applied research, or development work? Fourthly, there is evidence that standard R&D surveys tend to undercount R&D in small firms (Kleinknecht, 1991).

In comparison to R&D, the use of patent data as an indicator for outcomes of innovation is often evaluated as a second-best solution, although high-quality patenting databases have become available in the course of time. It has been noted (see for example Kleinknecht (1996)) that the use of patents as indicators of innovative output is problematic too. For example, many innovations are not patented, while the propensity to patent varies across sectors and firm size classes. Moreover, many patents are not transformed into commercially viable products or services and the economic impact of individual patents tends to differ considerably.

Since the 1980s, considerable efforts have been made towards the development of new and more reliable output indicators of innovation. Both the OECD and the Commission of the European Union have promoted the formulation of harmonized output indicators in innovation surveys. In 1993, the Community Innovation Survey was carried out in almost all West European countries, using the new output indicators. The most prominent output indicator is innovative sales, or the proportion of sales that is generated by a firm as a result of innovative activities. A clear advantage of this dimension of innovative outcomes is that it captures the confrontation of the (product) innovation with the demands of the market and thus is more close to the general accepted definition of innovation that includes the successful market introduction of the innovation.

A second dimension of innovation outcomes taken into account in this paper is the level of newness of the innovation. Often the newness of innovation is depicted on a scale ranging from incremental to radical, on which radical stands for paradigmatic technological change impacting on, and changing large parts of the economy. For two reasons, such an approach is not very applicable when doing firm-level research. First, the generation of truly radical innovations is extremely rare; therefore, using this definition would lead to the absence of observations at that end of the scale. Second, this definition takes an “objective” macro perspective in which external experts have to determine the level of newness of an innovation and its related economic and societal impact, which basically makes it inapplicable when conducting large scale firm-level research. Therefore, in this paper newness of innovation is defined as to what extent technologically products are improved versions of products that were already produced by the firm, products that are new to the firm, or products that are new to the firm's market.

2.2 External knowledge and the newness of innovation

From a theoretical perspective, external knowledge sources seem especially valuable for firms that develop highly new innovations, since these firms are most likely to require knowledge not available within the own firm. However, earlier research by, for example, Oerlemans et al. (1998), indicates that firms that develop highly new innovations reflect the 'lonely innovator' image, and tend to use external knowledge sources very sparsely. Based on these findings it can be argued that innovations with a very high level of newness can lead to a decrease in the importance of external resources (Maillat, 1991; Oerlemans et al., 1998). The reason being that if resource and knowledge heterogeneity becomes too large, the ability to make use of external resources decreases. Instead, firms that generate these innovations rely on their own internal knowledge generating capacity, like internal R&D.

Based on these earlier findings, it seems likely that there is an inversed U-shaped relationship between the newness of innovations and the importance of external knowledge sources. External knowledge is relatively unimportant for innovations with very low or very high level of newness, but of more importance for moderately new innovations.

As has been argued earlier, describing such a general relationship between the importance of external knowledge sources and the newness of innovation does not take into account that not all external knowledge sources are identical. It seems likely that firms that collaborate with universities gain access to different knowledge bases than firms that collaborate with competitors, buyers, or suppliers. The only handhold the literature seems to offer with regard to this issue is the distinction between sources of codified knowledge and sources of tacit knowledge (Howells, 2002). It is often argued that the utilization of codified sources of knowledge, such as the Internet and electronic databases is unlikely to lead to highly new products or services, since this knowledge is heavily standardized and often publicly available (Johnson et al., 2002). Instead, such codified sources of knowledge are generally thought to be only beneficial for the generation of improved versions of already existing products or services (Saviotti, 1998). Based on these insights, the following working hypothesis can be posed:

H1: The higher the utilization of codified sources of external knowledge by a firm, the higher its generation of incrementally innovative products and services.

With regard to more fine-grained differences between different types of external knowledge sources for the newness of innovation the literature seems lacking, with the study of Frishammar and Hörte (2005) as a noteworthy exception. Frishammar and Hörte find that tapping into the knowledge of customers, suppliers, and competitors (that together form one source of knowledge in their paper) is negatively associated with the innovative performance of firms, whereas tapping into the knowledge of "technological" partners (also one source of knowledge), such as universities and research institutes, is positively associated with the innovative performance of firms. However, this distinction is still rather coarse and does not make a distinction between different levels of newness of the generated innovations. As the matter a fact, Frishammar and Hörte (2005) only look at the production of radical innovations. Nevertheless, the following working hypotheses can be elaborated based on their insights:

H2: The higher the utilization of technological external knowledge sources by a firm, the higher its generation of radically innovative products and services.

H3: The higher the utilization of business organizations as sources of external knowledge by a firm, the lower its generation of radically innovative products and services.

Furthermore, based on the insights of Levy et al. (2003) some statements can be made with regard to the specific case of knowledge obtained from competitors. Since developing highly new innovations is, by definition, a very uncertain undertaking, the risks of opportunistic behavior by competitors are high. Furthermore, the expected “leverage” of this type of innovation is high. Due to both the risk of opportunistic behavior and high levels of “leverage” competitors are only likely to provide knowledge that can be used to generate relatively incremental innovations. Therefore, the following working hypothesis can be posed:

H4: The higher the utilization of competitors as sources of external knowledge by a firm, the higher its generation of incrementally innovative products and services.

The working hypotheses posed in the above are not based on an exhaustive and thoroughly tested theoretical and empirical basis. Moreover, these hypotheses are still phrased at a relatively high level of abstraction. It might be the case, for example, that there are significant differences between the effects of different types of codified knowledge on the newness of innovations produced by firms. Therefore, these hypotheses merely serve as the starting point for the empirical analysis of the data and the subsequent discussion.

3. Data and measurement

The research question posed in this paper will be answered by using data from the South African Innovation Survey 2001 (SAIS2001). The SAIS2001 questionnaire was based on the European Community Innovation Survey, but adapted to the South African context.[1] The survey was mailed to, in total, 7.339 firms. However, only 8.4% of these firms returned the survey. This is a low figure, but not uncommon for organizational research, which often yields relatively low response rates (c.f. Baruch, 1999). A telephonic non-response analysis among 462 firms was conducted. Questions were asked about specific reasons not to respond and about some firm characteristics, like for example R&D activity. The response to the non-response survey was very high (90%). Non-responding firms indicated that their reasons for not participating in the survey fell into two categories. Either they stated that their organization did not receive a copy of the questionnaire (52%), or a lack of time resulted in non-participation (33%). Amongst others, non-responding firms were asked whether they had

[1] See for more detailed information about the research design and the data collection procedure: Oerlemans et al. (2006).

technological innovations in the period 1998-2000 and to what extent their R&D activities were of a continuous nature. Of course, the same questions were asked to the responding organizations. A comparison of the response and the non-response group revealed no statistically significant differences. Therefore, the response group can be considered as representative of the total population of South African firms and no sample bias occurred. Therefore, the quality of the data is likely to be unbiased despite the relatively low response rate. Ultimately, this database contains information on the innovative activities and outcomes of 617 firms.[2]

To measure the utilization of external knowledge sources, firms were asked to indicate for fourteen different possible sources what the importance of a particular source was for its innovative processes. The possible answers ranged from (0) of no importance, to (3) very important. On the basis of the responses to this question, egocentric innovation networks can be constructed in which the own group, buyers, suppliers, competitors, consultants, public research labs, universities, innovation centers, and sectoral institutes can be discerned. Moreover, several other sources of external knowledge, such as new personnel, patents, professional literature, and electronic databases are included as well.

Several control variables, such as the size of the firm, its R&D intensity, the Pavitt-sector in which it carries out its main activities, and its level of internal knowledge utilization are included in this analysis as well in order to capture and correct for both firm internal and sectoral differences. Two variables measure the knowledge generation and utilization capacity within the firm, namely the R&D intensity of the firm (% of total workforce engaged in R&D) and the utilization of internal knowledge of the firm. This last variable is a sum score of the importance (ranging from (0) no importance, to (3) very important) of six different internal knowledge functions of a firm.[3] The sector in which a firm is active is measured by the Pavitt-taxonomy, which consists of four distinct sectors (see: Pavitt, 1984). For this analysis, the "supplier dominated" sector is chosen as the reference group. Finally, the size of a firm is measured as the natural logarithm of the amount of employees it has.

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[2] See the original research report by Oerlemans et al. (2003) or the publications based on this research report by Oerlemans and Pretorius (forthcoming), Oerlemans et al. (2006), and Rooks et al. (2005) for more detailed information about the SAIS2001.

[3] Namely: (1) purchasing function, (2) marketing function, (3) research function, (4) development function, (5) engineering function, and (6) production function.

The newness of the innovations has been measured by looking at whether or not a firm produced technologically improved products, products that are new to the firm, and/or products that are new to the market as a whole. Instead of employing the incremental - radical dichotomy, three levels of relative newness are discerned in this research. This somewhat more fine-grained distinction allows for a more detailed analysis. Moreover, the percentage of turnover generated by each of these categories of innovations is taken into account as well. The distributions of these variables are illustrated in Figures 1 and 2. Figure 1 clearly illustrates that the newer the innovations, the lower the percentage of firms that has sales in that category. This indicates that more firms are involved in developing improved products than in developing highly new innovations. Figure 2 illustrates that, even after purging all observations with 0% sales generated by innovative products, the data is highly skewed to the left. Most firms obtain a relatively low percentage of their sales from innovative products. This observation holds for all levels of relative newness of innovations.

Insert Figure 1 here

Insert Figure 2 here

In order to check for collinearity of the data, a problem that seems likely to occur in this case, so called "auxiliary regressions" are estimated. In these regressions the dependent variable is *one* of the independent variables of the main analysis. The independent variables of these regressions are *all other* independent variables of the main analysis. This regression is performed for all independent variables of the main analysis. Auxiliary regressions are a better test for collinearity than pairwise correlations, since collinearity may involve more than two of the independent variables, which may not be detected when examining pairwise correlations (Hill et al., 2001). If the R^2 of these auxiliary regressions is high, above 80% as a rule of thumb, this variable suffers from a problematically high degree of collinearity.

From Table 1 it becomes clear that the R^2 of the models without the "internal knowledge" variable are sufficiently low. When this variable is included, however, the R^2 of the regression models for variable 13, 14, and 20 becomes sufficiently high to warrant some further investigation.

Insert Table 1 here

In Table 2, the pairwise Pearson correlations are given for the variables 13, 14, and 20. From Table 2, it can be derived that besides correlating highly with each other, a problematic pairwise correlation exists between utilizing knowledge from competitors and the variables under scrutiny. Moreover, the utilization of internal knowledge correlates highly with the utilization of knowledge flows from several external sources. Even though these correlations seem logical from a theoretical point of view, they are somewhat problematic with regard to the empirical analysis. Therefore, models with and without the “internal knowledge utilization” variable have been estimated for each level of newness of innovation. Furthermore, the interpretation of the models with the “internal knowledge” variable included should be done cautiously.

3.1 Methodology

Due to the skewness of the data discussed and illustrated earlier, the estimation of a Tobit II Model is appropriate (Hill et al., 2001: 191-192; Verbeek, 2004: 218-236). The Tobit II procedure, sometimes denoted as a “nested Tobit” analysis as well, consists of two steps. The first step is a logistic regression procedure to estimate whether the percentage of sales obtained with products with a certain level of newness are either 0 or larger than 0 for each firm. For this logistic regression, all firms with a percentage of sales higher than 0% in a given category of newness are coded with a 1, and all other firms are coded with a 0. Subsequently, in step two, the 0-observations are filtered out, and an ordinary least squares is estimated for all values larger than 0 to explain the actual percentage of sales obtained with products in for a certain level of newness. The Tobit II procedure differs from an ordinary Tobit procedure by allowing variables to have different signs and significance levels in both steps of the analysis.[4] This procedure is necessary in order to correct for the larger percentage of observations

[4] For a detailed (mathematical) description of this procedure and the underlying algorithms see Verbeek (2004).

without any innovative sales in the dataset. For the sake of simplicity and transparency, the results of both parts of the analysis are presented separately in this paper.

When performing the second part of the analysis, problems with heteroskedasticity of the data were encountered. These problems are caused by the fact that, even when all observations without any innovative sales are deleted, the data is skewed to the left. The level of heteroskedasticity of the data was significant according to both the Goldfeld-Quandt test and White's Test for Heteroskedasticity. In order to correct for heteroskedasticity, the standard errors for the OLS-regressions are computed using White's estimator (Hill et al., 2001: 240). The sample is sufficiently large to allow for this choice.

4. Results

The first part of the analysis consist of a binary logistic regression in which the dependent variable is coded as "0" if the firm had no innovative sales at that level of newness and "1" if it did. The independent variables in this analysis were all sources of external knowledge flows, as well as the size of the firm, its R&D intensity, the Pavitt-sector of the firm, and its use of internal knowledge. Due to the problems of collinearity, models with (1, 3, and 5) and without the internal knowledge variable (2, 4, and 6) have been estimated. The results of these logistic regressions are reported in Table 3.

Insert Table 3 here

Several interesting findings can be derived from Table 3. First, the role of knowledge that can be obtained from other establishments of the same firm (own group variable) seems to fade out as innovations become more new, which indicates that knowledge that is already readily available within (other parts of) the firm can be used to improve products, but seldom leads to really new products.

Second, the impact of using knowledge from new personnel on the production of innovative products is negative, especially with regard to the production of goods that are new to the market as a whole. This might indicate that it is difficult for firms to internalize the knowledge possessed by new personnel.

Third, using knowledge from competitors is positively associated with the production of innovative products for all categories of relative newness. The relation is strongest, however, for innovations with a low level of newness. The size of the coefficient is quite large when compared to the impact of other sources of external knowledge, especially for the generation of improved products.[5] Both the size of the coefficient and its significance drop when the internal knowledge variable is introduced in the model, but this effect is largely due to collinearity problems discussed earlier.

Fourth, the use of knowledge from public research labs is negatively associated with the production of innovative products for innovations with low newness levels. This might indicate that firms that turn to these organizations for knowledge find it hard to bridge the gap between the scientific knowledge produced by these organizations and the practical applications of this knowledge in marketable products. The fact that the size of the coefficient in model 1 and 2 is very large might be explained by the fact that firms that try to utilize the knowledge possessed by public research labs are only interested in highly new innovations and neglect the improvement of existing products.

Fifth, the use of knowledge from patents is positively associated with the generation of innovative products with high levels of newness, but not with very low newness levels. This might indicate that the codified knowledge available in patents might allow firms to develop truly new products by combining their own knowledge with knowledge from other technological fields. This finding is, however, in contradiction with the statement often found in the literature that codified forms of knowledge only contribute to innovations with low newness levels.

Finally, the R&D intensity of a firm is only positively associated with the generation of products that are new to the market, but not to the more incremental levels of newness. On the other hand, the utilization of internal knowledge is positively associated with the generation of innovations at all levels of newness, but the effect is the strongest for improved products.

[5] Because the scales of all the "external source" variables are identical, the size of the coefficients can be directly compared, even though they are not standardized.

From the above it can be concluded that the roles of different types of external knowledge are not identical to each other. For example, obtaining knowledge from competitors has a positive impact on the development of innovations within a firm, whereas focusing strongly on obtaining knowledge from public research labs seems to reduce to likelihood of a firm producing any innovative products or services. Furthermore, the role of a single type of external knowledge can differ for different levels of newness of innovations. For example, the knowledge that can be obtained from other establishments of the same business group has a positive impact on the existence of innovations with low levels of newness, but no effect on the existence of innovations that are new to the market as a whole. The knowledge that can be obtained from patents, on the other hand, is only of influence on the development of relatively new innovations and not on the development of improved versions of products or services.

The fact that the effect of internal knowledge utilization is significant in all models supports the claim that the importance of external knowledge is sometimes exaggerated in the literature, and that the role of the knowledge of the firm itself should not be underestimated (Oerlemans et al., 1998).

From the fact that all models are significant at the 1%-level and the relatively high pseudo-R^2 of the models, it can be concluded that the models are quite capable of explaining which firms have successfully developed innovations and which have not. They tell very little, however, about the magnitude of the innovative performance of these firms. Therefore, several additional models were estimated in the second step of the Tobit II analysis, in which only firms with innovative sales are included. In these models, the percentage of sales obtained from innovative goods is used as the dependent variable. Once again, three levels of relative newness of innovations are used. The results of these estimations can be found in Table 4.

Insert Table 4 here

From Table 4, it immediately becomes clear that these models (7 through 12) fit the data much less compared to the binary regression reported in Table 3. Three models (model 7, 11 and 12) are insignificant (even at the 10% level), and model 8 is only significant at the 5% level. The same conclusion can be drawn when looking at the R^2 of the models, which is significantly lower than in the binary regressions.[6] Therefore, it can be concluded that the access of firms to external knowledge bases and the utilization of internal knowledge functions are better predictors for the distinction between innovative firms and non-innovative firms than for the level of innovativeness of firms. Nevertheless, some interesting findings can be derived from Table 4, and the comparison between Table 3 and 4.

First, being connected to competitors does not seem to have any effect on the percentage of sales a firm obtains from innovative products. This finding is interesting, since it is quite different from the findings presented in Table 3. A possible explanation for this difference might be that being connected to your competitors gives you information about the activities that they are undertaking and, thus, gives some insights into the direction in which the market might develop. Monitoring this knowledge is necessary to successfully develop and introduce any kind of innovative products to the market, but is, by itself, not a sufficient source to do so. In other words, acquiring knowledge from competitors is an important prerequisite for developing innovative products, but other (external) sources of knowledge are necessary to realize these innovations as well. A similar reasoning might apply to the utilization of external knowledge from other establishments of the same firm, new personnel, buyers, suppliers and consultants.

Second, acquiring knowledge from public research labs is positively associated with the percentage of sales a firm obtains from improved products, but not for the other categories of innovative products. This is striking, since collaboration with public research labs was negatively associated with being an innovative firm in this category of newness (see Table 3, model 1 and 2). This might indicate that many firms that try to utilize knowledge from public research labs have difficulties in doing so. If they are successful, however, they experience an increase in their innovative sales.

Third, the utilization of knowledge from universities is positively associated with the percentage of sales a firm obtains from products that are new to the firm. This is interesting

[6] Even though one cannot directly compare the pseudo R^2 of a binary regression with the R^2 of an ordinary least square estimation, the differences in this case are so profound that this conclusion seems valid.

since collaboration with universities had no significant effect in the binary regressions. This might indicate that, similar to the reasoning applied to the collaboration with public research labs, that it is difficult for many firms to utilize the knowledge of universities, but that it can offer useful knowledge to those firms that are able to utilize it.

Fourth, the impact of the utilization of patents and innovation centers is consistent between Table 3 and 4. Again, it is found that utilizing patents has a positive effect on the generation of the two more radical types of innovative products and services. These consistent findings put further stress on the general assumption that codified sources of knowledge are only conducive to more incremental types of innovative activities.

Fifth, the use of electronic information sources is very strongly associated with the percentage of sales a firm obtains with products that are new to the firm. This indicates that codified sources of knowledge can serve as a valuable input for the innovative processes of firms.

Finally, the role of the internal knowledge utilization is much smaller when compared to model 1 through 6. This might be an indication that utilizing your internal knowledge is a prerequisite for being innovative in the first place, but is, by itself, not sufficient to generate the new knowledge necessary for innovation other than improving products or services you are already producing. In order to generate new knowledge, you need either external sources (especially for products new to the firm) or R&D (especially for products that are new to the market as a whole). These findings are in line with the notion of absorptive capacity, which states that not all firms are able to utilize the knowledge that is available in their environment, but that a firm needs a basis to which it can relate this new knowledge (Cohen & Levinthal, 1990).

5. Discussion and conclusions

On the whole, the findings presented in Table 4 are substantially different from the findings presented in Table 3, which substantiate the choice of the Tobit II method. These differences indicate that the same variable can play a different role in both sets of analyses. This finding is interesting by itself, since it might indicate that utilizing several sources of knowledge (such as competitors and internal knowledge) is conducive to innovation, but is not sufficient to generate any innovative sales on its own. Instead, having access to these types of knowledge might serve as a source of absorptive capacity or, in other words, as a catalyst of innovations.

Furthermore, the role of a variable can also differ between the different levels of relative newness of innovations (with patents as a good example). These differences are more complex than might be expected, however. It is not simply the case that codified sources of knowledge are important for incremental innovations and tacit sources of knowledge for radical innovations. Therefore, the relationship proposed in working hypothesis one is too simplistic. Instead, some sources of codified knowledge are even negatively associated with the generation of innovations with a low level of newness (especially professional literature), whereas others are conducive to highly new innovations (especially patents). What does seem to hold, however, is the general idea posed by Oerlemans et al. (1998) that external sources of knowledge are especially important for innovations with a medium level of newness, but less so for very new innovations and innovations characterized by very low newness levels. For the former category, R&D seems to be the most important knowledge sources, whereas for the latter category, the utilization of internal knowledge is sufficient to generate innovative sales.

Working hypothesis two stated that the utilization of knowledge from technological external knowledge sources would be associated with the generation of innovations with higher levels of newness. This hypothesis is partly supported by the findings. Acquiring knowledge from universities is indeed associated with higher newness levels of innovative output. However, acquiring knowledge from innovation centers is negatively associated with innovative output. Furthermore, acquiring knowledge from public research labs and innovation centers has a negative impact on the probability to be innovative in the first place. On the whole, working hypothesis two seems to be too simplistic as well. More appropriate would be an approach that distinguishes between the attempt to utilize knowledge from technological sources and the success of these attempts.

Acquiring knowledge from business sources is positively associated with being innovative (with the exception of new personnel), but does not seem to have any predictive value for the magnitude of the innovative performance. In contrast to of Frishammar and Hörte (2005), no negative effect on the generation of more radical types of innovation could be found.

Therefore, no support for working hypothesis three was found. Given the findings presented in the above, it seems that external knowledge from business sources serves as a catalyst for innovation.

Finally, with regard to the role of collaboration with competitors, it can be concluded that the working hypothesis posed earlier is too simplistic as well. Collaborating with competitors seems to have a positive effect on being innovative. This positive effect, however, holds for all newness levels of innovations and not only for innovations with low levels of newness. Nevertheless, the effect is stronger and larger for low newness levels than for high levels, which partly corresponds to working hypothesis 4. Furthermore, there seems to be no effect of collaborating with competitors on the percentage of sales that is obtained from innovative products, neither for low nor high levels of newness. Therefore, the following statement can be formulated: *"collaborating with competitors serves as a catalyst for innovative processes, but is, by itself, an insufficient source of knowledge to generate innovative products."*

On the whole, the findings presented in this paper have shown that the impact of utilizing external knowledge flows from different sources differs between knowledge sources and the level of newness of the generated innovative outputs. Thereby, they point to a gap in the current literature, which treats all kinds of external knowledge sources as identical. Moreover, it indicates that the relations proposed in the literature are often too simplistic. A first attempt to capture the complexity behind the relation between the utilization of external knowledge sources and the relative newness of innovations has been made with this paper. However, more theoretical and empirical work is necessary in order to come to well founded statements.

An interesting reflection on the findings of this research can be inspired by the tension between the need to generalize the empirical results of this research on the one hand, and some theoretical views in innovations studies on the other hand. Ideally, the value of research findings increases when results can be generalized to other situations and contexts. However, especially the national system of innovation literature argues that nation-specific factors shape innovation processes (of firms). Nationally specific structures of organization of the innovation process and institutions cause differences between countries, which results in the conclusion that there are clear limitations to the extent in which county-specific findings can be generalized. Therefore, the question is to what extent the results of this research can be generalized beyond the South African context? It seems that such generalizations are limited. A first indication is the negative influence of the use of the knowledge of new personnel on innovation. Normally, one would expect a positive association. However, in the South African context this is not a surprising result, since the country is confronted with a number of worrying developments (Blankley & Kahn, 2005):

- A large part of the (Black) workforce is not or low-educated;
- There is a substantial migration of highly educated, mostly white, workers to countries like Australia and England (the 'brain drain');
- The number of full-time equivalent researchers devoted to R&D dropped with 11% between 1991 and 2001;
- There has been a fairly strong movement of R&D staff from R&D positions to non-R&D positions, which was not countered by an inflow of young researchers.

These developments indicate that South African innovators have to deal with growing human resource deficits inhibiting the generation of innovations.

Moreover, it was found that knowledge obtained from other establishments of the same business groups and especially obtained from competitors increased the likelihood of the production of product innovations with low levels of newness. Recent research (Rooks & Oerlemans, 2005) showed that these other establishments are often of a foreign nature, whereas competitors were by far the most important external knowledge sources used by South African innovation firms. Combined these observations results in the conclusion that the South African system of innovation seems to be in an imitation-mode. Buys (2002) labeled this state of affairs as South African being a technology colony: product and processes are improved using imported and imitated, most often foreign, technological knowledge, with large parts of the revenues flowing to companies outside South Africa. This conclusion is further strengthened by the fact that South Africa's R&D expenditure as a percentage of GDP is very low compared to other comparable countries (2000: 0.8%, Blankley & Kahn, 2005) resulting in a relatively low innovative capacity. As a result, the findings presented in this study are not likely to hold in highly developed and industrialized regions, such as Western Europe and the United States. However, generalizations to other regions with similar characteristics (i.e. economies in imitation mode that suffer from a brain drain) seem possible.

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Table 1. Auxiliary regressions

Variable number	Variable	R-square	R-square
1	External knowledge flows: Own Group	24,6%	27,9%
2	External knowledge flows: New personnel	44,1%	45,2%
3	External knowledge flows: Buyers	49,1%	50,7%
4	External knowledge flows: Suppliers	58,5%	58,8%
5	External knowledge flows: Competitors	57,2%	64,0%
6	External knowledge flows: Consultants	41,1%	44,9%
7	External knowledge flows: Public research labs	61,6%	63,3%
8	External knowledge flows: Universities	56,9%	59,3%
9	External knowledge flows: Innovation centres	54,5%	60,8%
10	External knowledge flows: Sector institutes	51,0%	51,2%
11	External knowledge flows: Patents	33,3%	36,4%
12	External knowledge flows: Electronic information	45,5%	47,6%
13	External knowledge flows: Professional literature	55,8%	**73,0%**
14	External knowledge flows: Exhibitions	65,1%	**70,6%**
15	R&D intensity	14,8%	16,7%
16	Firms size	21,8%	22,0%
17	Pavitt Sector: Scale Intensive[a]	32,0%	32,8%
18	Pavitt Sector: Specialized Suppliers[a]	26,5%	27,1%
19	Pavitt Sector: Science Based[a]	29,7%	31,6%
20	Internal Knowledge Utilization	-	**75,9%**

[a]: Binary logistic regression has been used since the dependent variable is dummy-coded. The reported measure is the Nagelkerke's Pseudo R-square.

Table 2. Pearson correlations

Nr	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
13	External knowledge flows: Professional literature	0,26	0,42	0,51	0,50	**0,60**	0,39	0,42	0,46	0,28	0,45	0,43	0,54	-	**0,68**	0,20	0,22	0,03	0,10	0,07	**0,68**
14	External knowledge flows: Exhibitions	0,32	0,50	0,53	**0,63**	**0,64**	0,47	0,41	0,52	0,39	0,51	0,42	**0,60**	**0,68**	-	0,21	0,21	0,04	0,11	-0,01	**0,67**
20	Internal Knowledge Utilization	0,47	**0,60**	**0,63**	**0,65**	**0,75**	0,58	0,52	0,52	0,43	0,47	0,44	0,54	**0,68**	**0,67**	0,29	0,32	0,10	0,22	0,09	-

Figure 1. Percentage of firms with innovative sales per category of relative newness

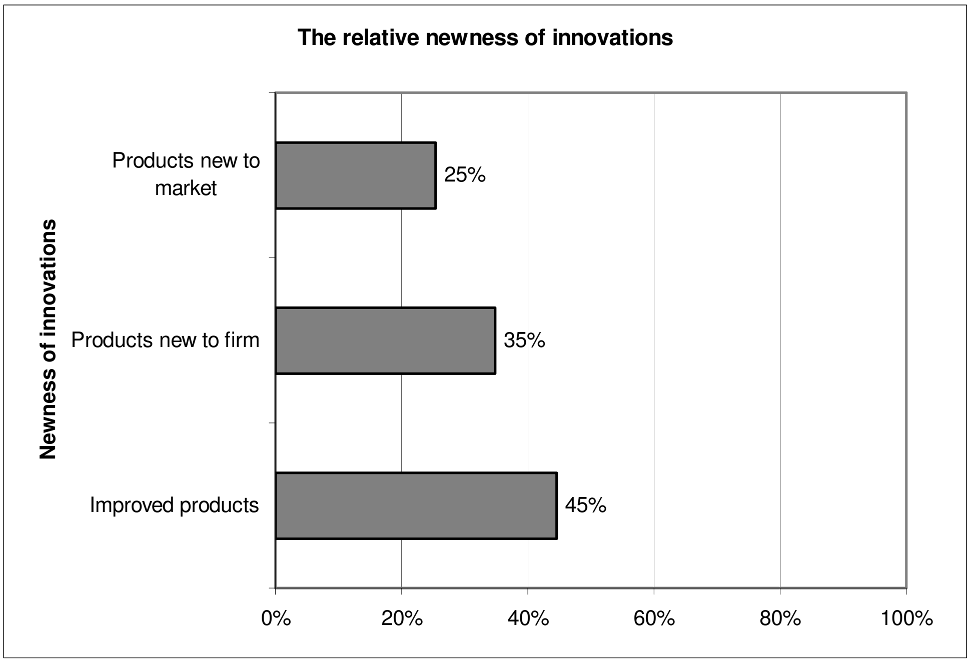

Figure 2. Distribution of percentage of innovative sales per category of relative newness

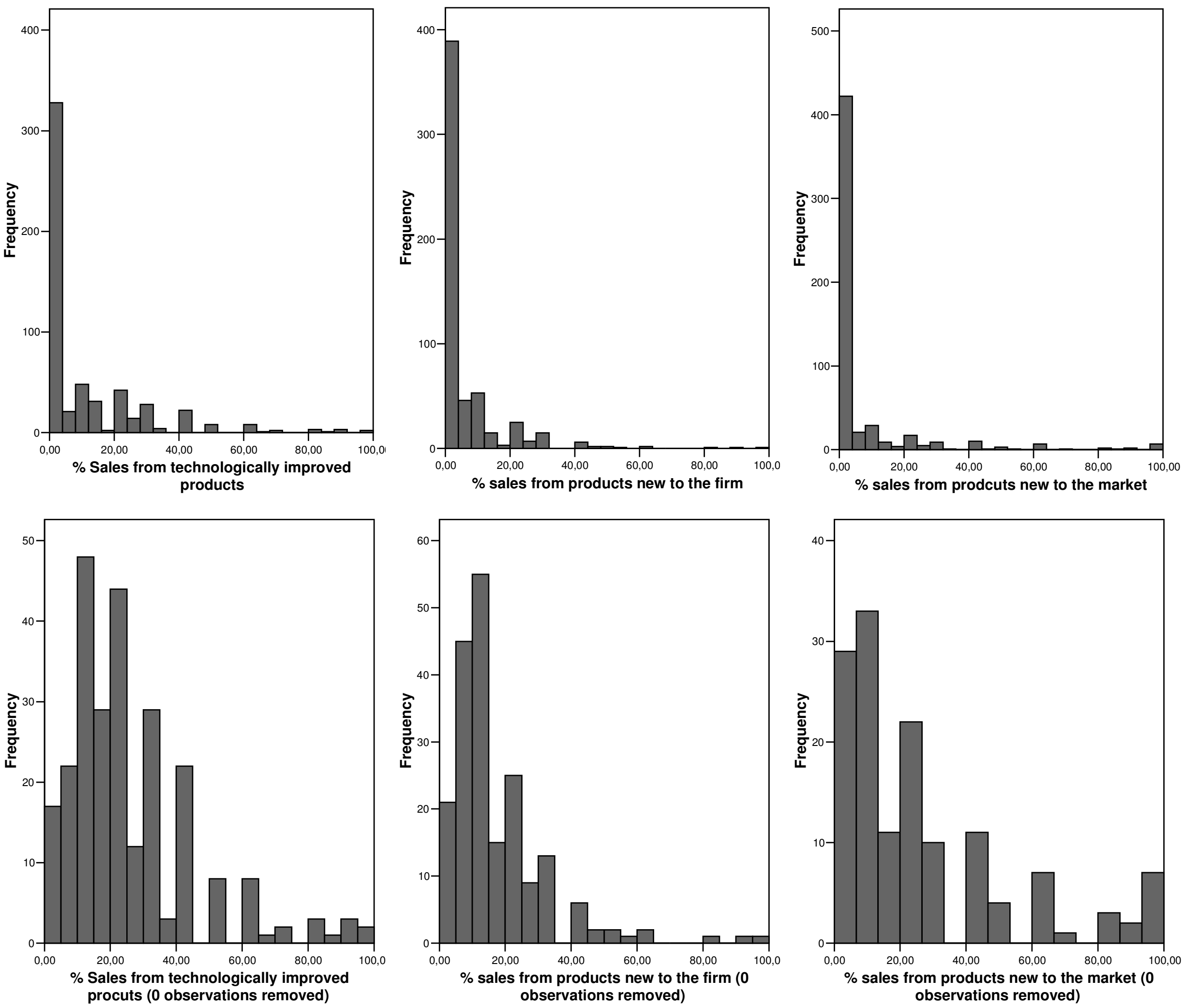

Table 3. Binary logistic regressions

	Improved products		New to firm		New to market	
	Innovator yes/no		**Innovator yes/no**		**Innovator yes/no**	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	**-5,438*** **	**-4,586*** **	**-5,488*** **	**-5,367*** **	**-4,589*** **	**-4,213*** **
External knowledge flows: Own Group	**1,013*** **	**0,736*** **	**0,515*** **	**0,394** **	0,174	0,009
External knowledge flows: New personnel	-0,360	**-0,820** **	0,164	0,103	**-0,537** **	**-0,722*** **
External knowledge flows: Buyers	**0,497* **	0,193	**0,469** **	0,316	**0,494** **	0,304
External knowledge flows: Suppliers	0,376	0,149	0,009	-0,161	**0,334* **	0,242
External knowledge flows: Competitors	**1,278*** **	**0,892*** **	**0,757*** **	**0,482** **	**0,792*** **	0,350
External knowledge flows: Consultants	**0,709*** **	0,044	**0,357* **	0,150	**0,354* **	0,181
External knowledge flows: Public research labs	**-1,567*** **	**-2,140*** **	-0,388	-0,589	-0,592	**-0,686* **
External knowledge flows: Universities	-0,325	-0,147	0,437	0,437	0,148	0,077
External knowledge flows: Innovation centres	-0,339	-0,601	**-1,157*** **	**-1,096** **	-0,404	-0,368
External knowledge flows: Sector institutes	0,377	0,153	-0,409	-0,479	-0,194	-0,246
External knowledge flows: Patents	0,242	0,038	**0,885** **	**0,668* **	**1,001*** **	**0,779** **
External knowledge flows: Electronic information	0,331	0,166	**0,512** **	0,370	0,080	-0,271
External knowledge flows: Professional literature	0,152	0,119	-0,191	-0,105	-0,062	0,133
External knowledge flows: Exhibitions	0,450	0,619	0,343	0,281	0,143	0,145
R&D intensity	11,158	6,674	1,170	0,333	**9,186* **	**7,582* **
Firms size (ln)	0,100	-0,122	**0,201* **	0,139	0,056	-0,093
Pavitt Sector: Scale Intensive	**-0,944** **	**-1,517*** **	**-0,625* **	-0,586	-0,536	**-0,804* **
Pavitt Sector: Specialized Suppliers	**0,973* **	0,799	-0,043	-0,441	0,760	0,511
Pavitt Sector: Science Based	-0,364	**-1,695** **	0,571	0,392	0,361	-0,033
Internal Knowledge Utilization		**0,485*** **		**0,208*** **		**0,263*** **
N	401	401	402	402	395	395
Nagelkerke's pseudo R-square	70,4%	79,6%	55,3%	61,3%	47,0%	55,4%
Significance	0,0000	0,000	0,000	0,000	0,000	0,000

Table 4. OLS regressions for cases with an innovative performance larger than zero

	Improved products		New to firm		New to market	
	Only >0		Only >0		Only >0	
	Model 7[b]	Model 8[b]	Model 9[b]	Model 10[b]	Model 11	Model 12
Constant[a]	5,702	5,246	2,890	4,827	9,829	11,786
External knowledge flows: Own Group	-0,011	-0,058	0,018	0,028	0,056	0,007
External knowledge flows: New personnel	0,077	0,058	0,030	0,035	-0,133	-0,126
External knowledge flows: Buyers	-0,046	-0,058	**0,169***	**0,179****	0,083	0,074
External knowledge flows: Suppliers	0,066	0,053	-0,075	-0,059	0,042	0,025
External knowledge flows: Competitors	0,136	0,105	0,009	0,016	0,028	-0,046
External knowledge flows: Consultants	-0,027	-0,076	-0,044	-0,021	-0,067	-0,078
External knowledge flows: Public research labs	**0,234***	**0,347*****	0,026	0,083	-0,089	-0,038
External knowledge flows: Universities	-0,113	-0,094	**0,304*****	**0,294*****	0,120	0,158
External knowledge flows: Innovation centres	-0,111	-0,205	**-0,196***	**-0,252****	-0,056	-0,097
External knowledge flows: Sector institutes	0,082	0,105	-0,103	-0,068	-0,029	-0,029
External knowledge flows: Patents	-0,008	-0,002	**0,224*****	**0,259*****	**0,190****	**0,183****
External knowledge flows: Electronic information	**0,155***	0,112	**0,350*****	**0,374*****	-0,059	-0,092
External knowledge flows: Professional literature	**-0,165***	**-0,244****	**-0,179****	**-0,238****	-0,092	-0,070
External knowledge flows: Exhibitions	-0,050	-0,007	-0,052	-0,031	-0,009	-0,002
R&D intensity	0,135	0,110	-0,023	-0,013	**0,274*****	**0,262*****
Firms size	0,110	-0,013	-0,032	-0,046	0,029	-0,046
Pavitt Sector: Scale Intensive	-0,127	**-0,156***	-0,095	-0,072	0,003	-0,025
Pavitt Sector: Specialized Suppliers	**0,138***	0,104	-0,055	-0,053	-0,028	-0,024
Pavitt Sector: Science Based	-0,027	-0,113	-0,016	-0,011	-0,001	-0,033
Internal Knowledge Utilization		**0,254*****		-0,046		0,124
N	174	174	174	174	164	164
R-square	14,8%	20,4%	26,2%	26,8%	14,5%	16,6%
Significance	0,125	0,021	0,000	0,000	0,143	0,116

a: non-standardized

b: corrected for heteroskedasticity