ABSORPTIVE CAPACITY AND INNOVATIVE PERFORMANCE: A HUMAN CAPITAL APPROACH

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In relation to firms' innovative performance this study investigates the importance of human capital on the firms' absorptive capacity. The estimation of an ordered probit model including 1544 firms from the manufacturing and service industry in Denmark shows that the share of highly educated employees, application of human resource management practices within the firm, and development of a closer relationship with both vertically related actors and knowledge institutions, is not only positively correlated with the ability to innovate but also negatively correlated with the degree of innovative imitation. Finally, work experience among managers, heads of departments, and employees at the managerial level is negatively associated with the ability to innovate for science-based and ICT intensive firms, thus indicating the importance of updating the skills of the employees in these high-tech sectors.

Keywords: Cooperation; education; human resource management practices; work experience; innovative performance

JEL classifications: J24, L60, L80, O32

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1. INTRODUCTION

It is generally recognized that, in the current economic context, the technological element is of crucial importance in securing competitive advantage for the individual firm, nation and the world economy as a whole. Scholars dealing with technological change may use different approaches, but they tend to agree upon the fact that inter-firm relations are of crucial importance to technological development.

Although knowledge received from external partners seems to be important and widespread among firms, managing external relationships is a difficult task. Besides the problem of finding the right person/partner - “know-who” - difficulties in assimilating and exploiting the information is also a problem. One of the most comprehensive and well-known contributions to this issue refers to the concept of “absorptive capacity”, in which internal capability and external collaboration are viewed as complementary (Cohen & Levinthal, 1989; 1990).

This complementarity has been illustrated in a number of studies by, for example, using traditional science indicators such as R&D or patents (Arora & Gambardella, 1990; Gambardella, 1992; Tripsas, 1997).

Other studies have moved away from the traditional indicators and have instead focused on the human capital involved in the processes. Mangematin and Nesta (1999) argue that highly educated employees in particular, through their daily tasks, will increase the stock of knowledge of the organization. They will further encourage relationships with other individuals with similar competencies outside the firm, thus facilitating access to external networks of knowledge, especially in the case of utilizing scientific knowledge (Rothwell & Dodgson, 1991). Carter (1989) argues that employees with high levels of education are the main contributors to know-how trading due to the high levels of knowledge embodied in these people which implies that they will be in a better position to recognize and value new external knowledge.

Besides formalized knowledge, tacit knowledge is an important component of innovation (Rosenberg, 1982; Dosi, 1988; Senker, 1995). Absorptive capacity may be developed through the accumulation of experience and this kind of firm-specific knowledge, that is, knowledge established through learning by doing, may be measured by work experience of the employees. (Romijn & Albaladejo, 2002) finds that work
experience obtained in either multinational or large domestic firms in the UK by founder/manager(s) has an influence on firms’ innovative capabilities. But prior work experience in public R&D institutions and having a degree in science and engineering were also shown to have an impact.

A third element, on which Cohen and Levinthal placed less emphasis, is the organizational setting within which the employees operate. They point out that cross-function interfaces such as those connecting R&D, design, manufacturing and marketing increase the absorptive capacity. Also, practices such as rotating R&D personnel through other units within the firm are important. In general terms, restructuring of employment relations in the form of Human Resource Management practices (HRM) has been shown to have positive linkages to innovative performance (Michie & Sheehan, 1999). Laursen & Foss (forthcoming) go one step further and find that complementarities between HRM practices have a positive influence on innovative performance.

Finally, Cohen and Levinthal (1994) recognize the importance of the strength of the external relationships in the development of absorptive capacity. Development of closer relationships may contribute to a firm’s absorptive capacity because such relationships may create and strengthen information channels and “thicken” the knowledge flow, hence increasing the efficiency of the transfer of tacit knowledge.

According to the discussion, both general knowledge in terms of formal education, firm-specific knowledge in terms of work experience, the organizational set-up and, finally, development of a closer relationship with external actors matter for the determination of absorptive capacity, thus leading us to a widening of the concept giving more justice to the importance of human capital.

Besides incorporating a fourfold approximation of absorptive capacity to our empirical data, this study goes further. Instead of focusing on intermediary outcomes such as citations or patents, we capture directly the frequency of innovation, which, according to Acs and Audretsch (1988), is the most direct measure of innovative activity. Finally, the whole economy is analyzed, thus making it possible to check for sectoral differences.
The rest of the paper is organized as follows: Section 2 describes the data set; section 3 outlines the model while section 4 presents the results. Finally, conclusions and implications are provided in section 5.

2. DATA

Two databases have been combined in order to carry out the analysis. One is a survey on organizational and technological change (1993-95). The survey was carried out in 1996 at Aalborg University and was submitted to almost 4000 firms from the manufacturing and service sectors, where firms with 10 employees or more were selected. All firms with at least 100 employees were selected due to the fact that large firms are most likely to carry out organizational change. The overall response rate was 48% (1900 firms), and in the manufacturing and service sectors the response rates were 52% and 45% respectively. The second database is the integrated database on the labor market (IDA), which includes register data on each individual in Denmark for the period 1980-97. The two databases were merged, and along with data for the period 1993-95, IDA data for 1990-97 were included. The merged database is constructed in such a way that each firm has to be represented in all years, which reduces the number of firms from 1900 to 1544.

3. MODEL

On the basis of the theoretical and empirical discussion, a model is estimated in which whether or not a firm innovates is used as dependent variable, and absorptive capacity and traditional control variables as independent variables. The basic structure of the model may be specified as follows:

\[ y = f(\beta_1 z + \beta_2 q) \]  

(1)
\(y\) represents the innovative activity of the firm, \(z\) and \(q\) are vectors containing proxies for absorptive capacity and other standardized variables used in the literature explaining the innovative activity of the firms.

\(y\) expresses the innovativeness of the firm on an ordered scale from 0-3. 0 is equal to a non-innovator firm (N=761), 1 indicates that the firm has introduced a product/service in the period of 1993-95 that is new to the firm only (N=584), 2 indicates that the firm has introduced an innovation that is new in the Danish context (N=110), and, finally, 3 indicates that the firm has introduced an innovation that is new to the world (N=89). Thus category 1 and 2 measures the degree of imitative innovations while category 3 measure innovation in the strict sense.

\(z\) includes four variables representing measures needed in the organization in order to assimilate and utilize external knowledge. First, \(HIEDU\) measures the share of employees who have an academic degree. Second, \(EXPE\) measures the average work experience of the employees. In order to focus upon those employees in the organization who are the most influential in the development process, managers and heads of departments as well as workers at the managerial level have been taken into account. Third, an \(HRM\) index developed in Gjerding (1997) is applied. This includes \(HRM\) practices such as (i) interdisciplinary workgroups, (ii) quality circles, (iii) systems for collection of employee proposals, (iv) planned job rotation, (v) delegation of responsibility, (vi) integration of functions and (vii) performance related pay. Firms using 0-2 practices are considered as having a low level of development, 3-4 practices as medium, and 5-7 as a high level of \(HRM\) practices. Finally, \(EXTERN\) takes out three values and indicates the degree to which firms have developed closer relationships with external actors such as customers/suppliers on the one hand and knowledge institutions on the other hand.\(^2\) The first category of firms includes those that have not established closer links to any of the external actors. The second category represents firms that have developed closer relationships with either customers/suppliers, as pointed out by (Lundvall, 1988; von Hippel, 1988), or with knowledge institutions.\(^3\) The final category

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\(^2\) The descriptive statistics and questionnaire can be viewed in Lund and Gjerding (1996).

\(^3\) Regardless of innovative activity the firms are asked: “To which extent has the firm developed a closer relationship with the following actors during 1993-95”.

\(^4\) Knowledge institutions express whether the firm had developed a closer relationship with institutions such as technical support institutions or universities, or with consultants. Information from these partners requires higher absorptive capacity due to the higher level of sophistication.
includes those firms that have developed closer relationships with both types of actors and thus have developed closer relationships with a more complete network of actors.

$q$ contains four standard control variables, the first of which is sectoral affiliation (SECTOR). Although different taxonomies exist, for example Schumpeters Mark I and Mark II (Malerba & Orsenigo, 1995), Pavitt’s taxonomy, with four sectors representing the manufacturing sector and five sectors representing the service firms, is applied. One of the criteria in this classification – sources of main knowledge inputs in the process of innovation, that is, internal versus external sources - is important with respect to the discussion of absorptive capacity.

One Schumpeterian hypothesis concerns innovation and SIZE. Schumpeter argued that innovative activity was positively correlated with firm size due to the existence and fixed cost nature of R&D departments. Although there have been contradictory results concerning this issue over the decades, the results seem to be in favor of a positive relationship (Acs & Audretsch, 1988; Brouwer & Kleinknecht, 1996). The third control variable, competition (COMP), was also touched upon by Schumpeter. Several measures have been applied, mostly the level of competition in terms of different ratios concerning concentration, and, over the last decades, contradictory results have been obtained. Schumpeter argued that concentrated industries were more innovative. Others have found that competition does not matter (Arvanitis S. & Hollenstein, 1996), while still others have found that increased competition favors innovation (Geroski, 1990). Alternatively, competition may become non-linear, where markets with an intermediate degree of market power favour innovation (Kleinknecht & Verspagen, 1989). COMP is measured in a slightly different way since the firms are asked about the rate of change in the level of competitive pressure within the period; thus, this study deals with intensification in competition instead of level of competition. Finally, the study controls for whether or not the firm is a subsidiary of a larger firm – SUBSID. Again, contradictory results exist, although the most recent studies tend to argue that a positive relationship exists due to the fact that subsidiary firms have access to the parent firm’s larger resource base and thus benefit in terms of innovative activity.

5 The categorization of the service firms is taken from Laursen (2000). For further details on the categorization, see Laursen (2000).
4. RESULTS

The dependent variable takes four discrete ordered values, so an ordered probit model is used for estimations. Table 1 reports the estimates of equation 1. In order to clarify sectoral influence Table 1 shows significant estimates only for industries according to the traditional standard industry classification and Pavitt sectors. For the latter model including Pavitt sectors (the preferred model) marginal effects are shown. However, as the estimates show, the results for the two different industrial sector classifications are very similar except for the coefficient of the share of highly educated employees.

Table 1 shows that the average share of highly educated employees (HIEDU) is only significant in model one and two, while it is insignificant in the third model including Pavitt sectors, although the estimate has the right sign. However, including industries according to standard industry classification, the share of academic employees becomes significant. A change in the share of academic employees decreases the probability for no innovation and increases the probability for producing innovation in the strict sense. Including the Pavitt sector variables instead of industry dummies in the model causes the variance explained in the share of highly educated employees to disappear. Hence, the share of highly educated employees between each Pavitt sector differs substantially, but the effect of the variance in the share of highly educated employees is less important for innovation within each sector.

The average work experience among top management (EXPE) is even less important. The specific knowledge through work experience does not show any significant effect on the degree of innovative activity. However, estimations of equation 1 for each of the nine sectors show that work experience among top management has a significantly negative impact only for firms in the science based and the ICT intensive sector, thus raising a question about the importance of updating the skills of the employees in these sectors. One reason may be that younger people are educated with the most recent knowledge about technology and management practices, whereas older

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7 Size was included in the model with Pavitt sectors, but was insignificant. As argued in Laursen (2000), the additional variance explained by size is removed when sector is included. Thus, the size of firms between the sectors differs, but the effect of the variance in size is not that important within each sector. Further, size is also one of the criteria behind the Pavitt taxonomy and one could therefore argue that the size variable should be omitted from the estimation.
people due to the increasing speed of new information may have difficulties in acquiring the latest advantages in information technology. Another explanation may be found in the set-up of the questionnaire that the study does not take into account that some innovations are more dependent on accumulation of knowledge. Although the sectoral classification partly takes this matter into account, another classification or another variable which treat this issue more carefully may be needed.

For all three models, the use of HRM practices is significant. Firms that apply HRM practices to a high degree are in a better position to innovate. The result is also in line with Michie and Sheehan (1999), who find that the application of HRM practices is more effective in influencing the innovative performance when these practices are applied together rather than alone. Hence, HRM practices are complementary to one another. However, the data do not take the problem of causation into account. There may be a reverse or a simultaneous causation. The links between product development and HRM practices are complex and difficult to disentangle and some of the HRM practices may be implemented in the later stage in the innovation process.

The firm’s development of closer external relationships (EXTERN), which can be argued to increase the potential effect of transferring information as well as tacit knowledge, is significant for all three models. This is especially the case for firms that have developed closer relationships to vertically related actors such as customers and suppliers, but also to knowledge institutions such as universities, and consultants. They do significantly better on innovative performance compared to firms that have only developed a closer relationship to one of the actors, and they do much better as compared to firms that have not developed closer relationships to their external actors. The result is not surprising because it is a well-known fact that external interaction matters (De Propris, 2000; Tether, 2002) but there seems to be evidence to highlight one point. The user-producer interaction may be argued to be extended to include actors that are not located in the value chain of the product/service.
Table 1: Ordered probit estimation of innovative performance and absorptive capacity

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model I</th>
<th></th>
<th>Model II</th>
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<th>Model III</th>
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<th>Marginal Effects for Model III</th>
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<tbody>
<tr>
<td>Intercep</td>
<td>-1.600</td>
<td>0.154</td>
<td>-1.217</td>
<td>0.206</td>
<td>-0.889</td>
<td>0.222</td>
<td>0.355</td>
<td>-0.214</td>
</tr>
<tr>
<td>HIEDEU - share of academic employees</td>
<td>1.892**</td>
<td>0.424</td>
<td>1.399*</td>
<td>0.520</td>
<td>0.772</td>
<td>0.541</td>
<td>-0.308</td>
<td>0.186</td>
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<tr>
<td>EXPE - work exp. of top-management</td>
<td>0.002</td>
<td>0.001</td>
<td>0.008</td>
<td>0.010</td>
<td>0.004</td>
<td>0.009</td>
<td>-0.002</td>
<td>0.001</td>
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<td>HRM - human resource management</td>
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<td>- high</td>
<td>0.537**</td>
<td>0.081</td>
<td>0.502**</td>
<td>0.081</td>
<td>0.460**</td>
<td>0.080</td>
<td>-0.183</td>
<td>0.111</td>
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<td>- medium</td>
<td>0.376**</td>
<td>0.076</td>
<td>0.351**</td>
<td>0.076</td>
<td>0.302**</td>
<td>0.077</td>
<td>-0.121</td>
<td>0.073</td>
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<td>- low</td>
<td>Benchmark</td>
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<td>Benchmark</td>
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<tr>
<td>EXTERN - closer relat. with extern. actors</td>
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<tr>
<td>- both</td>
<td>1.066**</td>
<td>0.116</td>
<td>1.026**</td>
<td>0.116</td>
<td>1.031**</td>
<td>0.118</td>
<td>-0.411</td>
<td>0.249</td>
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<td>- either vertical/know. inst.</td>
<td>0.811**</td>
<td>0.112</td>
<td>0.794**</td>
<td>0.112</td>
<td>0.787**</td>
<td>0.077</td>
<td>-0.314</td>
<td>0.189</td>
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<td>- none</td>
<td>Benchmark</td>
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<td>Benchmark</td>
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<td>Benchmark</td>
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<tr>
<td>SUBSID - belonging to a sub. firm</td>
<td>0.190*</td>
<td>0.065</td>
<td>0.191*</td>
<td>0.065</td>
<td>0.134*</td>
<td>0.066</td>
<td>-0.054</td>
<td>0.032</td>
</tr>
<tr>
<td>COMP - experienced increased comp.</td>
<td>0.238**</td>
<td>0.062</td>
<td>0.222**</td>
<td>0.062</td>
<td>0.234**</td>
<td>0.063</td>
<td>-0.093</td>
<td>0.056</td>
</tr>
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<td>SIZE - size of the firm</td>
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<td>- &gt; 50</td>
<td>0.196*</td>
<td>0.087</td>
<td>-0.002</td>
<td>0.105</td>
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<td>- 20-50</td>
<td>0.836</td>
<td>0.083</td>
<td>-0.010</td>
<td>0.090</td>
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<td>- &lt; 20</td>
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<tr>
<td>INDUSTRY DUMMIES - 2 digit level¹</td>
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<tr>
<td>- Construction</td>
<td>-0.624**</td>
<td>0.173</td>
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<tr>
<td>- Transport, storage and communication</td>
<td>-0.523*</td>
<td>0.196</td>
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<td>- Financial intermediation, business act.</td>
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<td>Benchmark</td>
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<td>Benchmark</td>
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<td>PAVITT SECTORS²</td>
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<td>- Crafts</td>
<td>-0.853**</td>
<td>0.188</td>
<td>0.340</td>
<td>-0.206</td>
<td>-0.072</td>
<td>-0.062</td>
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<tr>
<td>- Specialized services</td>
<td>-0.669**</td>
<td>0.179</td>
<td>0.267</td>
<td>-0.164</td>
<td>-0.057</td>
<td>-0.049</td>
<td></td>
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<tr>
<td>- Scale intensive services</td>
<td>-0.721**</td>
<td>0.234</td>
<td>0.288</td>
<td>-0.174</td>
<td>-0.061</td>
<td>-0.053</td>
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<td>- ICT intensive services</td>
<td>Benchmark</td>
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<td>N</td>
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<tr>
<td>% of correct predictions</td>
<td>60</td>
<td></td>
<td>60</td>
<td></td>
<td>61</td>
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<tr>
<td>Log likelihood</td>
<td>-1486</td>
<td></td>
<td>-1455</td>
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<td>-1450</td>
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<td>Restricted log likelihood</td>
<td>-1650</td>
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<td>-1651</td>
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<td>-1650</td>
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<tr>
<td>Likelihood ratio test</td>
<td>328.9</td>
<td></td>
<td>390.4</td>
<td></td>
<td>400.2</td>
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</table>

¹ insignificant industries: mfr. of textiles, wearing apparel, leather; mfr. wood prod., printing and publ; mfr. of chemicals, plastic products etc.; mfr. of other non-metalic mineral prod.; mfr. of basic metals and fabric metal prod.; mfr. of furniture; manufacturing n.e.c.; wholesale and retail sale, hotels and restaurants;

² insignificant sectors: supplier dominated, scale intensive, specialized suppliers, science-based, wholesale trade

Notes: ** significance at 1% level; * significance at 5% level
Instead, it is the whole network of external actors that matters. This is in line with Foray and Lundvall (1996), who argue that we are moving toward a networked learning economy where networks determine the relative success of the firms. Also, the rationale put forward by DeBresson (1999), that firms that interact with many rather than a few external actors, seems to be the most successful. Kaufmann and Tödtling (2001) emphasize that the likelihood for lock-ins can be minimized when a range of sources of knowledge is diverse, hence a complete network of external actors are involved in the development process. Besides lock-ins, complete networks also reflect the increasing division of labour which is present in the learning economy. However, as with the HRM practices there may be a problem of causation between a closer relationships and innovative performance in the sense that when firms become innovative they become more attractive to partners and thus increase their collaboration opportunities (Ahuja, 2000).

The degree of increased competition (COMP) shows the right sign and is significant for all models. Firms exposed to increased competition are, ceteris paribus, more likely to innovate.

Firms that are owned by a larger firm (SUBSID) show significant results in general, which suggests that subsidiaries are more likely to increase innovative performance due to access to the larger resource base of the parent firm.

The size variable is only significant when sector affiliation is not included. Firms with fewer than 20 employees are less likely to produce innovations in the strict sense compared to firms with more than 50 employees. The argument is well known since larger firms can more easily devote resources to the innovation process.

Finally, sector variables show that the service sector differs more in innovative performance compared to the manufacturing industry. One explanation may be that development of innovations is more important in the earlier stages of the value chain where ICT intensive/financial intermediation, business activities and manufacturing firms are placed. Further down the value chain, where the rest of the service firms are located, other elements such as personal contacts with customers are more important for survival than development of innovations. Instead, these firms rely on and receive innovations/knowledge from manufacturing and knowledge intensive service firms, as argued in Drejer (1998).
5. CONCLUSIONS

Over the past decades the use of external knowledge in the innovation process has grown in importance. Research has shown that increasing the firm’s internal capability is a prerequisite for effectively assimilating and utilizing this knowledge from the outside.

Application of an ordered probit model to our data shows that the application of HRM practices within the firm, and development of closer relationships with both vertically related actors and knowledge institutions, is not only associated with a firm’s ability to innovate, but also to produce more radical innovations, thus indicating an improved ability to deal with complexity (OECD, 2000).

A policy as well as a managerial implication might be to support the development of human resources by developing the organizational structure, culture and use of techniques to motivate a qualified labor force where for instance decentralization of responsibility to the organization’s employees is essential.

When the major sector variables are included in the model, the variance explained by the share of highly educated employees decreases. The share of employees with a higher education differs between sectors, but the effect of the variance in the share of highly educated employees is less important within any of the sector categories.

The results referring to external actors support the hypothesis that the importance of user-producer interaction might be broadened to include knowledge institutions. A development of a closer relationship with a network of actors can be beneficial in several ways. The uncertainty of technological development as well as opportunism will be reduced (DeBresson & Amesse, 1991). The growth of the knowledge economy will further increase the need for more efficient and trustworthy information. According to Powell (1990) this may be achieved through networks since information that passes through networks is “thicker” than information obtained in the market due to the fact that participants know each other. Further, the information will be “freer” than that communicated in a hierarchy, which is characterized by being more formalized.
With respect to knowledge institutions, it may be argued that firms that are able to utilize and assimilate this kind of sophisticated knowledge will be in a better position to adjust more rapidly to the changing environment. One problem with knowledge institutions compared to other types of external actors is that firms have difficulty determining the value of the information they buy. In the case of choosing a supplier, it is easier for the firm to know what it actually gets. Thus, an important task is to increase the transparency of the market for knowledge intensive services (Christensen et al., 2001).

The work experience of managers and heads of departments as well as of workers at the managerial level does not show any significant result at the general level, although estimation within each sector shows that the effect is negative for the two high-tech sectors, science based and ICT intensive services. A hypothesis might be that due to the rapid speed of new information, knowledge and skills of the employees in these sectors become outdated more quickly. Moreover, it may be of special importance to hire young educated people who are aware of the latest technologies and management practices, whereas older people are less up to date, not trained in the latest advantages in information technology. Continuous retraining is therefore important. However, more research is needed in order to get a better understanding on the impact of work experience on innovative performance, i.e. innovation dependency on knowledge accumulation.

Finally, there are sectoral differences, especially between firms in the non-manufacturing industry: ICT intensive services are the most conducive to innovation, while craft industries are the least conducive. One could hypothesize that many of the non-manufacturing industries are less dependent on innovative activity but more dependent on other factors such as personal contact with customers etc. Another argument concerns the relatively low level of competition in the service industry. Increasing the level of competition in the service industry may have a strong positive impact upon innovation. An implication could then be that the competitive pressure would spread to the rest of the economy through the backward linkages from the service industry.

Although this paper has brought a better understanding of how different kinds of elements associated with absorptive capacity behave, some limitations still remain.
Most of the variables in the estimation are survey specific. The lack of time in these variables makes it difficult to take the problem of causality into account. Therefore more research is needed in order to investigate the causation, for instance between HRM practices and external interaction on one side and innovation on the other. Moreover, are certain types of education more conducive to innovations than others? Are some types of work experience more important than others, for example, work experience achieved in the same sector compared to experience achieved from other sectors?

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