CESIS
Electronic Working Paper Series

Paper No. 31

Firm Location, Corporate Structure, R&D Investment, Innovation and Productivity [1]

Börje Johansson, Hans Lööf and Amy Rader Olsson

(JIBS, INFRA, CEFIN)

April 2005

The Royal Institute of technology
Centre of Excellence for Science and Innovation Studies
http://www.infra.kth.se/cesis
Corresponding author: hansl@infra.kth.se

[1] Status of the paper: The Paper has been accepted for presentations at conferences 2005 in Amsterdam and Uddevalla

Firm Location, Corporate Structure, Innovation and Productivity

April 28, 2005

Börje Johansson[Ψ], Hans Lööf[Ω] and Amy Rader Olsson[Φ]

Abstract

This study elucidates how firm location and corporate structure influence R&D-intensity, external collaboration on innovation, return on R&D and economic performance. The study, based on 1,907 firm level observations, essentially compare a functional region with four other regional areas in Sweden. In this context, the Stockholm region is assumed as an integrated functional urban region with innovation-proximity characteristics. The paper examines systematically the influence of location versus various firm characteristics. The econometric results suggest the following: First, a typical Stockholm firm has a significantly larger likelihood than other firms of being engaged in innovation activities. Second, among innovative firms, the R&D intensity and global collaboration on innovation is primarily determined by its corporate structure, not geographic location. Third, the embeddedness in regional and national scientific and vertical innovation systems is relatively more intense outside Stockholm. Finally, the advantage of being located within Sweden's most strongest concentration of R&D spending, universities, human capital and multinational enterprises with their global networks is reflected by a superior return on R&D investments and higher productivity, when controlling for firm size, human capital, physical capital, R&D-intensity, market orientation and sector classification.

Keywords: Regional economy, multinational companies, R&D, innovation, innovation system
JEL Classification: C21, G34, L22, O33

[Ψ] Economics, JIBS, Box 1026, 551 11 Jönköping and CESIS, The Royal Institute of Technology, 100 44 Stockholm, email: borje.johansson@ihh.hj.se
[Ω] CESIS, The Royal Institute of Technology, 100 44 Stockholm, email: hansl@infra.kth.se
[Φ] CEFIN, The Royal Institute of Technology, 100 44 Stockholm, email: arolsson@infra.kth.se

1. INTRODUCTION

This paper examines how firm location and corporate structure relate to innovation and productivity. The propensity for firms to agglomerate is associated with the benefits that large urban regions can afford, both proximity advantages and special qualities of regions in fostering innovation and economic growth. Large urban regions can be expected to have higher rates of innovation and adopt innovations more rapidly. See, for instance, Acs (1994) Glaeser (1999) and Harhoff (1999). However, the negative effects of congestion in very dense, poorly connected regions may temper innovation benefits from agglomeration.

Regional features can capture proximity externalities in the innovation process. What then is the role of corporate structure? A multinational firm is a multi-unit network in which knowledge can flow with small friction also over long distances. When located in a metropolitan region, such a firm can combine proximity advantages with network advantages.

This paper adds to the literature on innovation and localization in two respects. First, we include the issue of corporate ownership and structure in the analysis. R&D has become increasingly internationalized in recent decades. Studying 32 multinationals with headquarters in the US, Japan, Germany, France and the Netherlands, Kuemmerle (1999) reports that the share of R&D carried out outside a firm's home country boundaries was 6.2 percent in 1965. In 1995, the corresponding figure was nearly 26 percent. Zander (1994), Cantwell (1998) and others report similar findings.

Sweden's R&D activity reflects growing globalization and the proliferation of multinationals. Foreign-owned firms have increased their share of Swedish manufacturing production from 21 percent in 1985 to 34 percent in 2001. In addition, foreign-owned firms increased their share of R&D investments in Sweden to 40 percent in year 2001. In the same year Swedish firms produced almost half of their R&D efforts abroad (Lööf, 2005).

There is widely held agreement in the modern literature that an R&D facility's capacity to exploit and augment its technological competency is a function not just of its own resources, but also of the efficiency with which it can utilize complementary resources (formal and informal linkages) and complex interdependencies among small local geographical units. Our analysis looks closely at ownership as it related to local embeddedness in innovation systems in light of the globalization trends in R&D.

Second, the paper is one of the first attempts ever to use the Community Innovation Survey data for regional analysis within one country. The survey data has been merged with register data derived from annual accounts. The analysis includes both manufacturing and service firms.

This study highlights the importance of firm localization and corporate structure for technological improvement and innovation performance. The Swedish capital region (Stockholm) is compared with four

other Swedish regions: East Central Sweden, South Sweden, West Sweden and North Sweden. The Stockholm region is distinguished from other Swedish regions in several respects. First and foremost, the Stockholm region is a functional urban region proper. None of the other areas comprise a single (and integrated) agglomeration in the same way. Moreover, the concentration of multinational enterprises (MNEs) and universities is higher, and the share of innovative firms larger, in the Stockholm region than in other Swedish regions. The average firm in Stockholm has both a higher R&D-intensity and a higher human capital intensity compared to firms in other regions. Among innovative firms, the Stockholm region's share of newly established firms and of firms launching non-imitation innovations is larger compared to other regions. Notably, we observe that innovative firms in Stockholm are more self-sufficient than elsewhere in Sweden, in the sense that they participate less in formal cooperation on innovation activities with universities and public and private R&D laboratories.

In sum, the Stockholm region has a denser and richer economic environment than other parts of Sweden. Urban economic theory tells us that this should result in higher floor-space costs in Stockholm, and we would expect innovative firms in the Stockholm region to have higher sales value per employee than similar firms elsewhere in Sweden. The paper tests these hypotheses using empirical evidence. We also analyse whether or not the return to product innovations, measured as increased sales value per employee for new products, is higher in Stockholm.

This study uses an econometric framework to analyse the relationship between regional location, intellectual capital, corporate ownership and innovation activities. The study is based on 1 907 enterprise-level observations of which 43 percent are non-affiliated enterprises, 36 percent uninational enterprises and 21 multinational corporations. Thus, more than half of the enterprises are multi-unit firms.

This presentation is structured as follows. In section 2 we elaborate on the key questions posed in this study and relate them to recent literature. Section 3 introduces the data used. The methodology is discussed in Section 4. Section 5 presents the empirical analysis. Section 6 concludes**.**

2. BACKGROUND AND PREVIOUS RESEARCH

2.1 Innovation Activities and Knowledge Flows

In innovation processes, both knowledge and information are important inputs. In empirical studies such as this it may be difficult to know how, or if, respondents to innovation surveys are drawing distinctions between knowledge and information. However, many studies of innovation processes have focused on

knowledge as a critical innovation input. In other words, non-innovative businesses can use information, but innovation requires knowledge as well.

Knowledge is an input to an innovation process, which – if successful – generates new products and new production routines used by the innovating firm. Knowledge for innovation takes several forms: (i) scientific knowledge in the form of basic principles, (ii) technological knowledge in the form of "technical solutions", and (iii) entrepreneurial knowledge about product attributes, customer preferences and market conditions, business concepts etc. (Karlsson and Johansson, 2004). With these distinctions it becomes clear why knowledge networks may have many different participants representing different types of knowledge (Batten, Kobayashi and Andersson, 1989). Therefore, it is also useful to identify types of firm interactions (internal and external) used to obtain and generate information and knowledge for innovation activities.

The first type of interaction for innovation knowledge is that internal to the firm. This may be the result of formal knowledge transfer processes or "water cooler conversations." Several studies have noted the importance of both firm organization and of key individuals. An effective organization can facilitate the transfer of codified information among knowledge workers and also provide (or thwart) opportunities for sharing ideas and collaborating on new projects. Because knowledge has a strong tacit component, it is embedded in the firm's "knowledge workers". These workers are often mobile, so their role in diffusing knowledge includes both interacting with others in one firm and also imparting some of the knowledge gained during that tenure to future employers. Several studies have analyzed the mobility of knowledge workers and their role in diffusing knowledge among firms, and some have shown that firm hiring of key individuals is an effective knowledge transfer strategy supporting innovation. (see Karlsson and Johansson, 2004 for a review).

Firms also derive information and knowledge for innovation from their participation in external professional networks, often called regional innovation networks or regional innovation systems. A single firm will often simultaneously participate in a range of discrete or interlinked networks of suppliers, customers, or neighboring firms. (Karlsson and Johansson, 2004) This study uses the distinctions offered by Cox, Mowatt and Prevezer (2003) between a firm's horizontal and vertical innovation systems. Firms are embedded in horizontal innovation network relationships with similar firms (competing, consulting and collaborating) and in vertical innovation network relationships with suppliers and customers.

Finally, interaction with the scientific community is considered crucial for firms' innovation activities. Innovative firms are highly dependent on knowledge generated by local university R&D. The knowledge transfer between universities and industry may use many different links or mechanisms, (see Johansson and Karlsson, 2004 for a review). These channels of knowledge flows include (i) A flow of newly trained

graduates from universities to industry. (ii) Technological spillovers of newly created knowledge from universities to industry. (iii) Industrial purchases of newly created university knowledge or intellectual property. (iv) University researchers consulting to industry or serving on company boards. (v) University researchers leaving universities to work for industry. (vi) University researchers creating new firms, i.e. academic entrepreneurship[2]

In addition, universities may create incubators, enterprise centres and science parks to improve interaction with industry and to facilitate university knowledge transfers.

The specific role played by each these different links for the development of industry are not well understood (Karlsson & Manduchi, 2001). Moreover, the actual links between universities and industry have proved in many cases difficult to detect. However, recent studies have shown strong evidence of knowledge transfers and spillover flows, as demonstrated by joint distributions of university capacity and high technology sectors (Varga, 1997 & 2002).

The figure below summarises some of the most important knowledge and information flows for an individual firm's innovation processes. In the relation to the figure it may be argued that information about both customers and technical solutions flows with smaller friction when actors are in proximity to each other. The same conclusion can be drawn with regard to interaction with external knowledge providers. A multinational firm can benefit from proximity each of its several locations. However, empirical observations indicate that knowledge interaction within a multi-company concern may be much less dependent on the proximity principle (Andersson and Ejermo, 2004). The suggestion is that multinational firms internalize the knowledge interaction process, which may partly explain the very existence of multinationals.

[2] Slaughter & Leslie (1997) provide a comprehensive overview of the phenomenon in question.

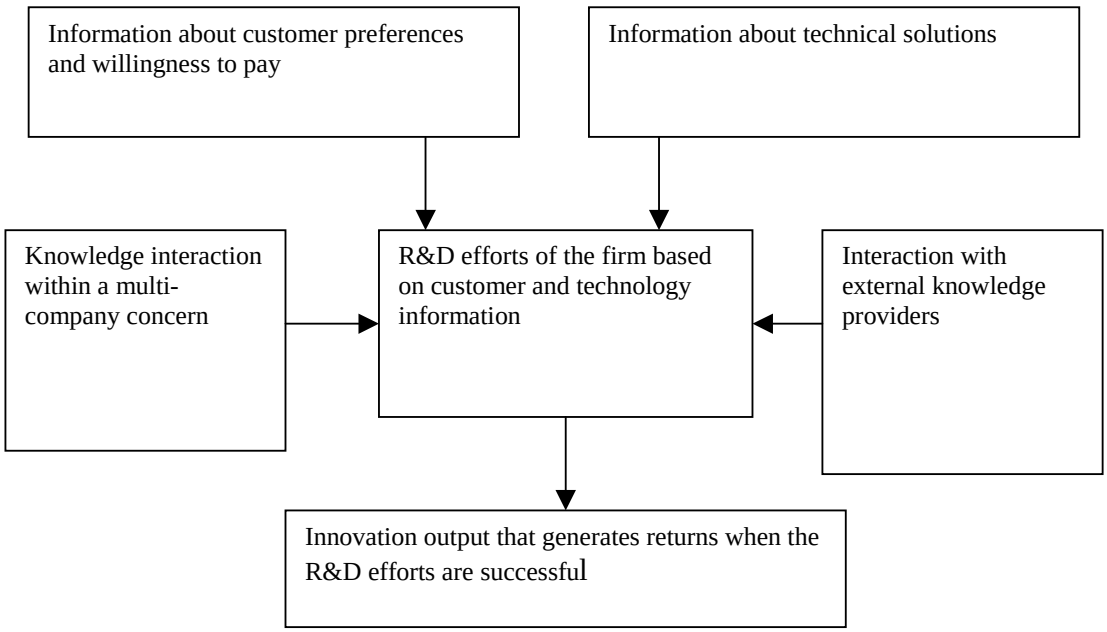

Figure 2.1: Knowledge and information flows in a firm's innovation process

2.2 Regions and innovation

A vast majority of scholars now agree that the proximity afforded by locating in large urban regions creates an advantage for firms by facilitating information and knowledge flows, following arguments presented early in Artle (1959) and Vernon (1962), and later in Glaeser (1999) and Feldman and Audretsch (1999). The nature of this phenomenon may be classified as a proximity-based communication externality (Fujita and Thisse, 2002).

The propensity for economic actors to agglomerate has encouraged many scholars to seek a better understanding of the special qualities of regions in fostering industrial growth. Variations in economic activity, income and productivity are apparent across geographic space, and the recent focus on knowledge flows, transactions and spillovers has prompted regional scientists and economic geographers to analyze the proximity and accessibility benefits of regions to innovating firms. Much of this analysis has been inspired by Marshall (1920) who identified the exchange of ideas as a type of externality leading to the agglomeration of economic activity. The exchange of ideas as embodied in technology spillovers have also been used by Henderson (1974) to account for the clustering of economic activity across space. Karlsson and Johansson (2004) argue that proximity is essential for all of the many types and forms of knowledge flows critical in innovation processes.

Within a functional region, delimited by housing and labour market perimeters, firms have better accessibility to customers, input suppliers, the scientific community, and competing firms—all important sources for intellectual capital and innovation–relevant knowledge and information. As noted earlier, labour mobility (often within a functional region) is also an importance source for both knowledge transfer and internal firm activities leading to growth and maintenance of intellectual capital. Some studies have estimated that proximity of within one hour's travel time from the firm location is sufficient to enjoy the positive externalities associated with agglomeration (e.g. Johansson, Klaesson and Olsson, 2002).

The literature presents a steady progression of methods and frameworks to investigate these relationships. These range from a general knowledge production function that embodies broad forms of distance-sensitive knowledge flows, including tacit as well as formal knowledge inputs, to more precisely specified models of knowledge flows and spillovers (particularly localized knowledge spillovers, LKS) through patents, patent citations and product innovations (Varga, 2002). LKS studies occasionally, but not always, distinguish clearly between pecuniary and technological externalities, their public and club good features, and various forms of private intellectual property. Mowery & Ziedonis (2001), for example, find knowledge flows from universities through market transactions to be more geographically localised than those operating through non-market "spillovers". This indicates that intense contact intensity is especially important when knowledge must be specified as a commodity for which property rights are clearly defined.

The size of the functional region is also considered relevant to its ability to invite, support and sustain innovative firms. Large regions offer special advantages to innovative firms in terms of knowledge flows and spillovers, since they offer both clusters in specific industries as well as a diverse range of industries. They combine the advantages of industrial clustering to knowledge transfer and spillover associated with Marshall, Arrow and Romer with the advantages of firm diversity for fostering and incubating innovative ideas as described by Jacobs (1969). Metropolitan regions thus represent areas of geographic space offering both network opportunities and agglomeration externalities beneficial to knowledge transfer. Network opportunities within a metropolitan region like Stockholm cover both local networks inside the region and global networks including electronic communication and air traffic.

Regions are also an important geographic level at which to study innovation processes and systems because they often represent the arena at which larger and smaller scales meet. At the scale of the metropolitan region, compromises are mediated among participants in the innovation system, and property rights issues are easier to solve for collaborating firms. In other words, urban regions may be the best scale at which to observe innovation systems at work, because they reflect processes of knowledge and information transfer at a variety of scales. (Lagendijk, in Fischer and Fröhlich, eds., 2001).

The Community Innovation Survey used as a basis for this and many empirical studies of innovation in European areas identifies sources of information for innovation as well as collaboration with national scientific, vertical and horizontal innovation systems. Firms responding to these surveys were not asked to specify the proximity of contacts and collaborators important to their innovation processes. However, we argue that cooperation with national level innovation systems is often manifested within regional borders and can therefore also be understood as approximating firms' embeddedness in regional innovation systems. Universities, for example, are an important part of a nation's innovation system, but many university-firm relations occur in proximity. Research universities have been identified by firms as location factors of growing importance (Hendersson, Jaffe and Trajtenberg 1995; Zucker and Darby 1998; Adams 2002; Hall, Link and Scott 2003; Zucker and Darby 2005). It has been suggested that regions with strong research universities have better opportunities to attract and support high technology industry than regions without such universities. Extending this idea, regionally based university research-parks can institutionally integrate university and firm resources (Luger & Goldstein, 1991). Several authors note the growing importance of network-type innovation interactions among firms, and private and public research institutions (Lundvall, 1992, Ed.; Nelson, 1993, Ed.; Etzkowitz & Leydersdorff, 2000; Charles, 2003).

2.3 Corporate Structure and Ownership

A firm's corporate structure can contribute both to the generation and transmission of knowledge and therefore to its stock of intellectual capital. Although these processes are complex and not completely understood, it is generally accepted that multinational firms may have advantages over uninational and unaffiliated firms in both the creation and transmission of knowledge for innovation (Pfaffermayer and Bellak 2002). Multinational firms, with many affiliated locations in several countries, have both the "reach" to access new information and the closed system necessary to protect temporary monopolies on intellectual capital.

Followers of Schumpeter argue that firms' incentive to innovate is their ability to enjoy at least temporary monopoly profits from their innovations. Multinational corporations thus seem to provide the best of both "worlds," both access to a large stock of external knowledge (due to the number of locations, including international locations) and the ability to share and develop proprietary information within the corporation. For a detailed discussion, see Dunnings (1993), Cantwell and Janne (1999), Kuemmerle (1999) and Criscuolo, Narula and Verspagen (2002).

This could indicate that formal incorporation of strategic partners within a multinational corporation is an attempt to appropriate their innovation output. Multinationals may also be more skilful in their interactions with R&D organizations, increasing their likelihood of benefiting from embeddedness in regional innovation systems. Moreover, multinationals tend to have a larger average size than other firms and can

thereby attract knowledge providers and specialized input suppliers. They have access to a richer base of customer and technological information and use the structure of the firm as a network for knowledge flows between the different units of the company.

Recent studies have confirmed the advantages of multi-location firms for innovative activities. Anderstig and Karlsson (1989) have shown that both advanced process innovations and all product innovations are positively correlated with the size of customer networks. A recent study by Ebersberger and Lööf (2004), using data from Swedish firms, indicates that multinational firms have a significantly larger probability of patenting and introducing radical innovations than uninational firms. Ebersberger and Lööf (2004) also note an important distinction between Swedish-owned multinational firms (domestic multinationals) and foreign-owned multinational firms. Domestic multinationals tended to be more embedded in their home country's innovation systems and had a higher value of R&D investments. However, the advantage of higher R&D intensity and possible technological knowledge spillover does not manifest itself in superior innovation output or productivity performance (the "return" on the innovation input investment). The tentative explanation offered is that domestic multinationals are using the home country for developing technological capacity exploited in affiliates abroad. Correspondingly, the innovation and productivity performance in foreign multinationals are partly returns on activities created in their home countries.

2.4 The Stockholm region: preconditions for innovation

The literature reviewed above highlights several reasons why regions may be an important scale at which to study innovation and why innovation activities vary across regions. The Stockholm region has many of the preconditions identified in the literature as essential to the creation of regional innovation systems supporting innovative firms. Compared to other Swedish regions, the Stockholm region has a higher share of R&D workers in the local labor supply, as well as a higher share of persons with university education (higher than average knowledge intensity). Nearly one in three multinational companies with facilities in Sweden are located in the Stockholm region; about one in two are in the Mälar Valley (which includes Stockholm). Since multinationals account for approximately 60 percent of industrial output and overall export, and almost 90 percent of Sweden's industrial R&D spending in 1990 (Fors and Svensson, 2002), the Stockholm region has by far Sweden's most significant concentration of R&D spending. As stressed in previous sections, the region can also offer multinationals an international air transport network.

The Stockholm region has better conditions than other Swedish regions for both short and long-distance interaction with R&D institutions and knowledge providers in general. As a large region with good connections, both among regional clusters and agglomerations and with other regions (both Swedish and international), Stockholm offers the agglomeration and network advantages described earlier as important to knowledge creation, transfer and spillover.

3. DATA

3.1 Data

This study uses data from the Community Innovation Survey (CIS) III for Sweden. The survey was conducted in 2001 and covers the period 1998-2000 for both the manufacturing sector and business services. The CIS has become a popular data source for statistical studies regarding innovation, since it allows for broad comparisons across firms and countries. However, its usefulness in assessing the importance of R&D and other innovation engagement in a regional perspective is somewhat limited. As noted above, firms are for instance not asked to report on the proximity of their domestic collaboration on innovation with external partners. The reporting units are firms, whose geographical locations are known, but R&D and production activities in plants located in other geographical areas are also included in data for the reporting unit. In order to reduce – but not eliminate – these problems, we have disaggregated the Swedish economy into five large regional areas (but see note regarding regional divisions below). In addition, we have assumed that the firms' plants as well as their collaboration in innovation processes, mostly are limited to the same localization areas as the reporting firm.

3.2 Variables

Table 1 introduces the selection variable "innovative firms" and the eight dependent variables posited as potential determinants for each specific variable. We define a firm as innovative if it satisfies one or more of the following criteria during the most recent 3-years period: it has introduced a new product, it has carried out a process innovation, or it has ongoing innovation activities. The study considers four different categories of innovation characteristics and their determinants. The four categories of characteristics are defined as follows: (i) *innovation input* measures the firms' expenditures on R&D and other innovation activities per employee, (ii) embeddedness in the domestic *science base* is a composite dummy variable indicating firms collaboration with universities, and private and public R&D laboratories, (iii) embeddedness in the domestic *vertical innovation system* is a composite variable indicating firm collaborate on innovation with customers and suppliers and (iv) *global collaboration on innovation* is intended to capture a firm's global collaboration on innovation with suppliers, customers, competitors, consultancies , commercial R&D laboratories, universities and public R&D laboratories

The study uses four different measures of firm output performance. The first is *non-imitation innovations*, a dummy variable that indicates if a firm has introduced a product partly or completely new to the market. The second measure is *innovation sales*, that is, sales income from new products. The variable *innovation sales* is expressed in intensity terms (per employee). The third output measure is *total sales per employee*, or gross labour productivity. Finally, we report *value added per employee.*

Table 2 describes the definitions of the explanatory variables. It should be noted that some of the endogenous variables presented in Table 1, also are used as explanatory variables in various equations. In the study the Stockholm region is compared with the rest of Sweden, divided into the four areas East Central Sweden, South Sweden, West Sweden and Other Sweden (mainly north Sweden).

Based on findings by Doms and Jensen (1999), Pfaffermayer and Bellak (2002), Bellman and Jungnickel (2002), Criscuolo and Martin (2004), Ebersberger and Lööf (2005) and others, we also control for differences in corporate structure when exploring the relationship between innovative activities and location. In order to do this we divide our sample into four separate categories of ownership: non-affiliate enterprises (firms not belonging to a group), uninational enterprises (firms belonging to a group with only domestic affiliates), domestic multinationals and foreign-owned multinationals.

The main firm characteristics in the study are firm size, gross labour productivity, profit margin, human capital (university educated/total employment), physical capital, knowledge capital (current and recurrent R&D), process innovation and the firms' recent history (establishment, merger and acquisition). In order to control for industry-specific factors, six sector dummies are included in the analysis, as well as information about the firm's most significant market.

3.3 Summary descriptive statistics

Tables 3-6 present descriptive and comparative statistics for all firms and innovative firms, respectively in the Swedish sample.

The sample contains 1,907 firms manufacturing and service enterprises with 10 or more employees, of which 815 (43 percent) are non-affiliated enterprises, 691 (36 percent) uninational enterprises and 401 (21 percent) multinationals. See Table 3**.** The Swedish capital Stockholm (Reg 1) has a smaller share of non-affiliated enterprises compared to other regions, and a larger share of multinationals. Nearly 50 percent of all multinational enterprises (MNE) in Sweden are located in Stockholm or its close neighbour-region East central Sweden (Reg 2).

The Stockholm region has a larger share of innovative firms (57 percent) compared to the other four regions (48-53 percent). A decomposition of the average figures in Table 4 shows that the relatively higher share of innovative firms in Stockholm is due to the region's lower share of non affiliated and uninational enterprises. Somewhat surprisingly, the share of innovative firms among multinationals is considerably smaller in Stockholm than in the four other Swedish regions.

Table 5 shows the distribution of firm size by region and corporate structure/ownership. Stockholm firms have on average twice the number of employees compared to firms in other parts of Sweden. MNE tend to

be larger than other types of firms, but in Stockholm multinational and multi-location uninational firms are not significantly different in size.

Tables 6 outlines the characteristics of firms regarding key economic variables. Panel A reports the statistics for all firms and Panel B only for the subgroup of innovative firms.

First, we see that sales per employee, expresses in mean, are somewhat larger in Stockholm than the average for Sweden. (Panel A). Second, in all five regions we find that multinational firms have higher average sales than other firms. Third, among multinationals, the highest ration of sales to employees, is found in West Sweden (Reg 4). Forth, Stockholm and West Sweden have lower profit margin than the three other regional areas.

The bottom part of Panel A shows that the typical firms in Stockholm is distinguish for the typical firm in other parts of Sweden in several respects; the number of employees is bigger, the share of newly established firms is larger, the human capital intensity is about twice as high as in Sweden as a whole, while the capital intensity and global market orientation is considerable lower. In addition, the occurrence of mergers and acquisition is somewhat more common in Stockholm than in Sweden as a whole.

The average innovative firm in Stockholm is clearly more R&D intensive than the average firm in other Swedish regions (Table 6, Panel B). But firms in Stockholm on average participate less with the Swedish scientific and vertical innovation systems. This is somewhat surprising given the literature on regional innovation systems, which assumes that such systems influence innovation activity and productivity in a positive way. In this study the better performance in the Stockholm region in innovation output cannot be attributed to conscious participation by firms in the regional innovation system. There are a number of reasons for this, one being the prevalence of multinational firms that can utilise a broad base of intra-corporate knowledge. Note again that the Community Innovation Survey data does not distinguish between regional and national innovation systems. In addition, Panel B shows that the difference between Stockholm and the mean for Sweden is small with regard global collaboration on innovation.

Innovation output, measured as new product sales per employee, is larger for the typical Stockholm firm. Non-imitation innovations are somewhat more common in Stockholm and West Sweden than in other regions. Notable is that the average innovative firm in Stockholm applies for patent in a smaller extent than other firms. The explanation is that Stockholm is a considerable more service-intensive region than other parts of Sweden. In particular, Stockholm has a far higher share of knowledge intensive services. In order to reduce space, application for patent as an indicator on R&D productivity is not included in the econometric analysis.

Among innovative firms, the ratio of sales to employees as well as the ratio of value added to employees (labor productivity) is bigger in Stockholm compare to other areas in Sweden.

Table 6, panel B notes that the pattern of other firm characteristics for innovative is similar to those reported for all firms.

The overall picture of the regional comparison indicate that some local characteristics that attract multinationals to Stockholm in a bigger extent relatively to other Swedish regions, such as presence of high quality labor force, high concentration of R&D, large local markets, good infrastructure, good administration, also enhance innovation output and productivity of other firms in this region. Thus, a priori we would expect that that the econometric analysis suggest that the typical innovative Stockholm firm is more successful in R&D and productivity performance than the corresponding firm in other parts of Sweden.

4. METHODOLOGY

First a probit equation is used for estimating the determinants to "innovative firms", that is firms reporting a product and/or process innovation and/or reporting ongoing innovation activities. Then a simple regression model with sample selection model is applied to determine the relationships among factors affecting firms' innovation activities as well as its economic performance. For estimation purposes we apply a two-step estimation procedure. A generalized Tobit model, comprising the selection equation (1) and a performance-equation (2), is consistently estimated by means of full maximum likelihood techniques, using observations on both innovative and non-innovative firms. The estimation procedure aims to solve the econometric problem of selection bias. Our approach takes into account that not all firms are engaged in innovative activities. When only the innovation sample is used in some part of the model, the firms are not randomly drawn from the larger population, and selection bias may arise. The two-step model used in the analyses accounts for this possible problem by formulating a specific choice structure. In the first step firms decide whether to engage in innovation activities or not (selection equation). Given that a firm has decided to invest in innovation projects, the 8 different performance variables are estimated. More specifically, we use the following model:

$$y_{0i} = \begin{cases} 1 & \text{if} \quad y_{0i}^{*} = X_{0i}\beta_0 + \varepsilon_{0i} > 0 \\ 0 & \text{if} \quad y_{0i}^{*} = X_{0i}\beta_0 + \varepsilon_{0i} \le 0 \end{cases} \tag{1}$$

$$y_{1i} = y_{1i}^{*} = X_{1i}\beta_1 + \varepsilon_{1i} \quad \text{if} \quad y_{0i} = 1 \tag{2}$$

where y_{0i}^{*} is a latent innovation decision variable measuring the propensity to innovate, y_{0i} is the corresponding observed binary variable being 1 for innovative firms and zero for others. y_{1i} signifies the 8 performance variables. X_{0i} and X_{1i} are vectors of various variables explaining innovation decision and innovation performance. The β-vectors contain the unknown parameters for each equation. ε_{0i} and ε_{1i} are independent and identically distributed drawings from a normal distribution with zero mean, jointly correlated.

In order to make a sensitivity analysis, the coefficient estimates from the selection equation is compared with the regression results from an ordinary least square estimation, which is in conjunction with equation (2).

5. RESULTS OF THE ECONOMETRIC ANALYSIS

5.1 The propensity to be an innovative firm

In accordance with the Oslo manual that guides the CIS (OECD, 1997), *innovative firm* in this paper is associated to new products, new processes and ongoing innovation. Our regression results from the probit equation (see Table 7) indicate that the propensity to be innovative is positively associated to be located in Stockholm. and to be a multinational firm. We also find that multinational firms have a greater likelihood of planning or launching new product and process innovations than other firms. The profitability, expressed as profit margin, is not a significant determinant to firm's decision engage in innovation activities.

In accordance with the Schumpeterian literature, Table 7 shows that "innovative firm", is an increasing function of firm size, physical capital (per employee) and human capital (share of the workforce with three years university education). See for instance Cohen and Klepper, 1996, Crepon et al 1998, Janz et al 2004. However, an average newly-established firm does not necessarily have a greater likelihood of being innovative than other firms. The incidence of merger or acquisition in a firm's recent history is positively associated with innovativeness. One explanation is that large firms may be "buying innovation" by acquiring smaller, innovative firms.

Innovativeness is related the firm's market profile and perspective, which is a classic result (e.g. Fischer and Johansson, 1994). A firm that recognizes the global market as its most important market has a significantly greater likelihood of being engaged in innovative activities compared to a firm selling on a local market. Finally and not surprisingly, high technology manufacturing firms, have a significantly greater propensity to be innovative than other firms.

5.2 Innovation investment and national innovation collaboration

Tables 8 and 9 report results for innovative firms, from the second step of the selection equation. In order to reduce space the coefficient estimates for the selection variables are not depicted.

Table 8, Panel A, Column 1, presents determinants R&D and other innovation input per employee. All else being equal, none of the point estimates for regions are significantly different from zero, implying that the location of the firm *per se* influences the size of R&D investments. However, the average domestic multinational enterprise invests considerably more on R&D compared to other domestic firms and foreign-owned enterprises. Persistent R&D expenditures are positively and closely associated with the size of innovation investments. This may be interpreted as a learning-by-doing effect in innovation processes and indicates the importance of accumulated R&D-investments. The results depicted in Column 1 also confirm previous studies regarding the sign of the firm size variable; innovation investment per employee is a decreasing function of firm size. Finally, process innovations are positively associated to the size of R&D investments.

Columns (2)-(3) in Table 8 show a starkly consistent pattern regarding collaboration on innovation with universities and vertical partners: Swedish-owned multinational firms have a significantly greater propensity to collaborate with domestic innovation systems than all other categories of firms in Sweden. There is also a significant and positive correlation between collaboration propensity and non-affiliate firms. Moreover, foreign-owned firms are more embedded in the vertical innovation system compare to the reference group (uninational firms).

At the same time, there is also a regional factor, such that firms – in general – located in Stockholm en have a *lower* propensity to utilize domestic innovation systems, compared to (nearly) identical firms in other Swedish regions. As noted, this is surprising given the wealth of literature on the importance of innovation systems in vibrant metropolitan regions. Either these firms are utilizing internal resources (at home and abroad) or they are enjoying the benefits of regional innovation systems in a typically Marshallian fashion; where pure spillover effects generate agglomeration externalities that "are, as it were, in the air." (Alfred Marshall, 1920). Collaboration on innovation is an increasing function of both current and persistent R&D-investments as well as firm size.

Column 4 reports that no regional differences in global collaboration on innovation can be found. Looking at the corporate structure variables, we see that multinational firms and non-affiliate firms are significantly more globally oriented in their innovation process compare to uninational firms. Notable is that the domestic multinational enterprises, which are more embedded in the regional and national innovation systems than other firms, are collaborating more with international partners than non-affiliate and uninational Swedish firms as well as foreign owned firms. Global collaboration on innovation is a positive function of both R&D-intensity, persistent R&D-investments and firm's size.

5.3 Innovation output and productivity

As described in Table 8, Panel B, Column6, none of the regional variables are significant when non-imitation innovations (products new to the market) are considered. In a sense this indicates that possible influences from the regional milieu are already taken into account by other determinants in the model. However, there is a corporate structure effect, reflected by a highly significant and positive point estimate for domestic multinationals and non-affiliate firms. There is also a path-dependence effect, such that enterprises reporting that they are engaged in R&D at a regular basis have a larger propensity to launch non-imitation innovations than other firms. The estimated relationship between non-imitation innovation and collaboration with the scientific innovation system is positive and significant. Evidence is also given that non-imitation innovation is a decreasing function of firm size. Process innovation is positively related to non-imitation innovations.

Column 6 describes the relationship between the log value of new product sales per employee and its determinants. Interestingly, there is a strong relationship between company location and this form of innovation productivity. The estimate for Stockholm is highly significant and quite sizable, 0.4. This means that, all other things being equal (such as firm size, industry classification, corporate owner structure and R&D-investment), a firm's research productivity is superior if it is located in Stockholm rather than other regions in Sweden. In other words, the return on R&D investment in terms of new product sales is evidently greatest for firms in the Stockholm region.

In accordance with the innovation literature, the point estimate for R&D and other innovation investments is closely associated with innovation output, and the order of magnitude, 0.13, is within the range of reported results from most other studies. There is also a corporate structure effect, such that the income from innovations is larger for multinational firms than for other firms. Somewhat unexpectedly, the three embeddedness variables are not significantly associated with innovation sales per employee, everything else equal.

Columns 7 and 8 report productivity estimates and distinguish between total sales per employee (gross productivity) and value added per employee (labor productivity proper). Both measures describes a significant regional effect – the average innovative firm in Stockholm has higher sales and value added per employee compared to a corresponding firm in other Swedish regions. Hence, the advantage of being located within Sweden's most significant concentration of R&D spending, universities, human capital and multinational enterprises with their global networks is reflected in a superior economic performance, controlling for factors such as firm size, human capital, physical capital, R&D-intensity, market orientation and sector classification.

No significant difference in gross or net productivity can be established between foreign multinationals, domestic multinationals and uninational firms. However, non-affiliated firms have significantly lower productivity than other firms. R&D-investment and the firm's capital stock are closely associated with the sales and value added performance. The point estimates for new establishments and mergers (sales and value added) and acquisitions (only value added) are both negative and highly significant.

A sensitivity analysis is presented in the Appendix. The results from the selection equation, which utilizes information from all observations in the sample, is compared with regression results from an (robust) ordinary least square regression based on only innovative firms. Only minor differences can be found between the results, and this differences is supposed to capture a small selection bias effect.

6. SUMMARY DISCUSSION

This study highlights how corporate ownership and structure, knowledge flows and location influence innovation activities among firms in Swedish regions. It attempts to illuminate some of the many complex relationships within firms and between firms and their interface with innovation systems (other firms, universities, public actors, etc). The data set contains extensive information on the characteristics of firms with ten or more employees. The survey-based data set has been merged with register data derived from annual accounts.

A major observation is (was) that the Stockholm region satisfies widely accepted criteria regarding what characterizes a functional urban region (Cheshire and Gordon, 1995). In particular, a functional region is integrated in such a way that frequent face-to-face contacts are possible, which facilitates knowledge flows that can stimulate innovation activities and knowledge interaction. The other four "regions" are not functional in the above sense; though West Sweden and South Sweden contain the metropolitan regions of Göteborg and Malmö respectively, they also comprise areas outside these metropoles. As a consequence,

our subsequent observations essentially compare a functional region with the rest of Sweden, decomposed into four areas.

The analysis starts with a probit model. In concordance with previous research, the regression results shows that the likelihood of being an innovative firm is influenced by a multinationality, human capital, firm size and belonging to a high technology manufacturing industry. In addition to this, the same regression reveals a significant location effect: the point estimate for Stockholm is positive.

Given these results, we continue to examine the subgroup of innovative firms across the five regional areas. The method is straightforward. A set of firm characteristics including corporate structure is used to explain innovation behaviour of individual firms as well as returns to innovation and economic performance.

In two cases, R&D-intensity and collaboration in global innovation system, there is no regional effect presence. However, scientific IS and vertical IS have a significant and negative parameter estimate for the Stockholm region. The finding on weaker embeddedness goes against hypothesis and suggestions in many contributions during recent decades. It has a wrong sign and it is highly significant. How can this be interpreted? One may conjecture that Stockholm offers greater opportunities to internalize R&D efforts, because of the region's greater knowledge intensity. It may also be that the innovation milieu in Stockholm allows for informal knowledge spillovers that are not captured in the CIS-survey.

With the above observations, are there any other positive consequences for R&D-intense firms of being located in the Stockholm region? The answer to this question is yes? We have three equations with a positive and significant regional dummy for the Stockholm region only.

In the first of these equation the dependent variable is new product sales, in the section total sales per employee, and in the third value added per employee.

Hence, the returns to innovation efforts are positively influenced by the Stockholm location. Combining this with our previous findings about formal R&D collaboration, this suggests the presence of pure (knowledge) spillovers in the Stockholm region. In addition, there is a positive Stockholm impact on sales per employee and value added per employee. The first impact allows Stockholm firms to afford higher floor-space cost, which in itself reflect positive agglomeration effects. The second impact, allows Stockholm firms to pay higher labour costs, and these are partly related to the comparative higher knowledge intensity of employees in Stockholm firms.

REFERENCES

Acs, Z.J. (1994) (Ed.), "*Regional Innovation, Knowledge and Global Change*, "London; Frances Pinter

Adams, J. (2002), "Comparative Localization of Academic and Industrial Spillovers," *Journal of Economic Geography* 2, 253-278.

Andersson, M. and Ejermo, O. (2004), How does Accessibility to Knowledge Sources Affect the Innovativeness of Corporations? – Evidence from Sweden, CESIS Electronic Working Paper Series, No 3.

Anderstig, C. and Karlsson, C. (1989), Spatial Diffusion of Information Technology in Sweden, in A.E. Andersson, D.F. Batten and C. Karlsson (eds), *Knowledge and Industrial Organization*, Springer-Verlag, Berlin, 157-176.

Artle R (1959), *The Structure of the Stockholm Economy – Toward a Framework for Projecting Metropolitan Community Development*, Business Research Institute of the Stockholm School of Economics.

Bellman, L and R Jungnickel (2002). "(Why) do Foreign-owned Firms in Germany Achieve Above-Productivity?" In R. Jungnickel (ed.), *Foreign-owned firms- are they different*?. Palgrave McMillan.

Batten, D.F., K. Kobayashi and Å.E. Andersson (1989), Knowledge, Nodes and Networks: An Analytical Perspective, in Andersson, Batten and Karlsson (1989) (Eds.), 31-46.

Cantwell, J., 1998. The globalisation of technology: what remains of the product-cycle model? In: Chandler, A., Hagström, P., Sölvell, Ö. (Eds.) The Dynamic Firm. Oxford Univ. Press, New York, pp. 263-288.

Cantwell, J., and O. Janne (1999) "Technological globalisation and innovative centres: the role of corporate technological leadership and location hierarchy," *Research Policy* **28** 2-3, 119-144.

Crepon, B., E. Duguet and J. Mairesse (1998), Research, Innovation and Productivity: An Econometric Analysis at the Firm Level, *Economics of Innovation and New Technology* 7, 115-158.

Criscuolo, P., R. Narula and B. Verspagen (2002). "The relative importance of home and host innovation systems in the internationalisation of MNE R&D: a patent citation analysis, " Ecis working paper series 02.12.

Criscuolo, C., and R. Martin (2004). "Multinationals and US productivity leadership: Evidence from Great Britain, " STI working paper 2004/5.

Charles, D. (2003), "Universities and Territorial Development: Reshaping the Regional Role of UK Universities," *Local Economy 18*, 7-20.

Cheshire, P.C. and I. R. Gordon, I.R (1995) "Territorial competition and the predictability of collective (in)action,". *International Journal of Urban and Regional Research*, 20, 383-399.

Cohen, M. and S. Klepper (1996), A reprise of size and R&D, *The Economic Journal* 106, 925-951.

Cox, H., S. Mowatt & M. Prevezar (2003), New Product Development and Product Supply within a Network Setting: The Chilled Ready-Meal Industry in the UK, *Industry and Innovation 10*, 197-217

Doms, M., E and J. Brandford Jensen (1998) "Comparing Wages, Skills, and Productivity between Domestically and Foreign- Owned Manufacturing Establishments in the United States," In R., E. Baldwin, R., E. Lipsey and J., David Richardson (Eds) *Geography and Ownership as Bases for Economic Accounting*, Studies in Income and Wealth, **59**, Chicago, University of Chicago Press, 235-258.

Dunning, J. H. (1993) " *Multinational Enterprises and the Global Economy*," Workingham U.K.: Adison Wesley Publishing Co.

Ebersberger, B. and H. Lööf (2004),"Multinational Enterprises, Spillovers, Innovation and Productivity," CESIS Electronic Working Paper Series, No 2*2.*

Ebersberger, B. and H. Lööf (2005) "Innovation Behavior and Productivity Performance in the Nordic Region. Does Foreign Ownership Matter?" CESIS Electronic Working Paper Series, No 27.

Etzkowitz, H. & L. Leydersdorff (2000), "The Dynamics of Innovation: From National Systems and "Mode 2" to a Triple Helix of University-industry-government Relations," *Research Policy 29*, 109-123

Feldman, M.P. and D.B. Audretsch (1999), "Innovation in Cities: Science-Based Diversity, Specialisation and Localised Competition," *European Economic Review 43,* 409-4293.

Fujita, M. and Thisse, J-F. (2002), *Economics of Agglomeration – Cities, Industrial Location and Regional Growth*, Cambridge University Press, Cambridge

Glaeser, E. (1999), "Learning in Cities," *Journal of Urban Economics 46*, 254-277.

Hall, B.H., Link, A.N., Scott, J.T. (2003) "Universities as Research Partners," *Review of Economics and Statistics*, May.

Harhoff, D (1999) "Firm Formation and Regional Spillovers," *The Economics of Innovation and New Technology* 8, 27-55.

Heckman, J.J. (1979), "Sample Selection Bias as a Specification Error," *Econometrica* 47, 153-162.

Henderson, J.V. (1974), "The Size and Types of Cities," *American Economic Review 89*, 640-656.

Hendersson, R., A. B. Jaffe and M Trajtenberg (1995) "Universities as a Source of Commercial Technology: A Detailed Analysis of University Patenting 1965-1988.". NBER WP 5068.

Jacobs, J. (1969), "*The Economy of Cities*," New York; Vintage.

Jaffe, A., M. Trajtenberg and R. Hendersson (1993) "*Geographical localisation of knowledge spillovers as evidence by patent citations*," Quartely Journal of Economics **108**, 577-599.

Janz, N., Lööf, H. and Peters, B., 2003 Firm Level Innovation and Productivity - Is there a Common Story Across Countries*? Problems and Perspectives in Management* 2, 184-204.

Johansson, B., Klaesson, J. and Olsson, M. (2002), Time Distances and Labor Market Integration, *Papers on Regional Science*, 81:305-327

Karlsson, C. and A. Manduchi (2001), "Knowledge Spillovers in a Spatial Context – A Critical Review and Assessment," in Fischer and Fröhlich (2001) (Eds.), 101-123

Karlsson, C. and B. Johansson (2004), "Towards a Dynamic Theory for the Spatial Knowledge Economy," CESIS Electronic Working Paper Series, No 20.

Kuemmerle, W (1999) " "Foreign direct investment in industrial research in the pharmaceutical and electronic industries – results from a survey of multinational firms," Research Policy **28** 2-3, 179-193.

Lagendijk, A. (2001), Scaling Knowledge Production: How Significant is the Region?, in M. Fischer and J. Fröhlich (eds), *Knowledge, Complexity and Innovation Systems*, Berlin: Springer-Verlag, pp. 79-100

Luger, M. & H. Goldstein (1991) *Technology in the Garden: Research Parks and Regional Development*, Chapel Hill; University of North Carolina Press

Lundvall, B-Å. (Ed.) (1992) *"National System of Innovation: Towards a Theory of Innovation and Interactive Learning*," Printer, London.

Lööf, H (2005), "Den växande utlandskontrollen av ekonomierna i Norden. Effekter på FoU, innoavtion and produktivitet," ITPS A2005:005.

Marshall, A. (1920), "*Principles of Economics*," 8th edition, London; Macmillan.

Mowery, D.C. & A.A. Ziedonis (2001), "The Geographic Reach of Market and Non-market Channels of Technology Transfer: Comparing Citations and Licences of University Patents," NBER Working Paper 8568, Cambridge, MA; National Bureau of Economic Research

Nelson, R. (Ed.), (1993) *"National Innovation Systems: a Comparative Analysis*," Oxford Univ. Press, New York.

Pfaffermayr, M and C. Bellak (2002). " Why Foreogn-owned firms are Different: A Conceptual Framework and Empical Evidence for Austria." In R. Jungnickel (ed.), *Foreign-owned firms- are they different*?. Palgrave McMillan.

Varga, A. (1997), "University Research and Regional Innovation: A Spatial Econometric Analysis of Academic Technology Transfers," Boston; Kluwer Academic Publishers

Varga, A. (2000), "Local Academic Knowledge Transfers and the Concentration of Economic Activity," *Journal of Regional Science 40*, 289-309

Varga, A. (2002), "Knowledge Transfers from Universities and the Regional Economy: A Review of the Literature," in Varga & Szerb (2002) (eds.), 147-171

Vernon, R (1962), *Metropolis 1985*, Cambridge Mass.: Harvard University Press

Zander, I. (1994), "The Tortoise Evolution of the Multinational Corporation-Foreign Technological Activity in Swedish Multinational Firms 1890-1990," Institute of International Business, Stockholm.

Zucker, L. G. and M. R. Darby (1998) "Capturing Technological Opportunity via Japan's Star Scientists: Evidence from Japanese Firm's Biotech Patents and Products," NBER Working. Paper 6360.

Zucker, L. G., M. R. Darby and M.B. Brewer (1998) "Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises," *American Economic Review* 88, 290-306.

Zucker, L. G. and M. R. Darby (2005) "Socio-economic Impact of Nanoscale Science: Initial Results and NonoBank," NBER Working paper 11181.

TABLES

Table 1: Variables, explained.

Dependent variables	**Definition**
Innovative firm	Innovative firms are firms reporting a product and/or process innovation and/or reporting ongoing innovation activities.
Innovation input	The firms expenditures on R&D and other innovation activities per employee, log.
Embeddedness in the regional science base	Composite dummy variable indicating if the firms collaborate on innovation with universities and private and public R&D laboratories
Embeddedness in the regional vertical innovation system	Composite dummy variable indicating if the firms collaborate on innovation with customers or suppliers
Global collaboration on innovation	Composite dummy variable indicating if the firms collaborate globally on innovation with suppliers, customers, competitors, consultancies , commercial R&D laboratories, universities and public R&D laboratories
Non-imitation innovations	Dummy variable, indicates if the firm has introduced a product with is new or significantly improved to the market
Innovation sales	The firms sales incomes from new products per employee, log
Gross labour productivity	Sales per employee, log
Net labour productivity	Value added per employee, log

Table 2: Variables, explanatory

Explanatory variables	Definition
Regional localization	
Stockholm	
East Central Sweden	Uppsala, Sörmland, Örebro, Östergötland
South Sweden	Blekinge, Skåne
West Sweden	Västra Götaland, Halland
Other Sweden	Småland, Öland, Gotland, Värmland, Dalarna, Gävleborg, Västernorrland, Jämtland, Västerbotten, Norrbotten
Firm structure	
Non Affiliated Enterprises	Domestically-owned firms without affiliates
Uninational Enterprises	Domestically-owned firms belonging to a group with only Swedish affiliates
Domestically-owned Multinational Enterprise	Domestically-owned firms belonging to a group with foreign affiliates
Foreign-owned Multinational Enterprises	Foreign-owned firms (belonging to a group) with
Firm characteristics	
Size	Number of employees
Gross productivity	Turnover per employee
Profit margin	Profit as a share of turnover
Human capital	Share of the employment with a university degree
Physical capital	Tangible assets
Innovation input	See table 1
Persistent R&D	Dummy for continuously R&D engagement
Process innovation	Dummy variable indicate whether the firms has introduced onto the market a new or significantly improved process
Newly established	The enterprise has been established during the last three years
Recent history of merging and acquisition	The enterprise has been involved in M&A during the last three years
Collaboration on innovation	
Embeddedness in the regional science base	See table 1
Embeddedness in the regional vertical innovation system	See table 1
Global collaboration on innovation	See table 1
Market	
Significant market area - local	The firms' most significant market
Significant market area - national	The firms' most significant market
Significant market area - global	The firms' most significant market
Sector	
High technology manufacturing sector	Nace 353, Nace 2423, Nace, 30, Nace 32, Nace 33
Medium high technology manuf. sectors	Nace 24 excl Nace 2423, Nace 29, Nace 31, Nace 34, Nace 352, Nace 359
Medium low technology manuf.sectors	Nace 23, Nace 25, Nace 26, Nace 37, Nace 28, Nace 351, Nace 354
Low technology manufacturing sectors	Nace 15, Nace 16, Nace 17, Nace 18, Nace 19, Nace 20, Nace 21, Nace 36, Nace 37
Knowledge intensive services	Nace 64, Nace 65, Nace 66, Nace 67, Nace 71, Nace 72-74
Other services	Other services than Knowledge intensive services

DESCRIPTIVE STATISTICS

Table 3: Number of observations

	REG 1	REG 2	REG 3	REG 4	REG 5	SWE
Non Affiliate	160	103	125	181	246	815
Uninational	144	105	93	135	214	691
Multinational	117	67	58	78	81	401
Average	421	275	276	394	541	1,907

Table 4: The share of innovative firms[3]

	REG 1	REG 2	REG 3	REG 4	REG 5	SWE
Non Affiliate	0.47	0.44	0.42	0.39	0.37	0.41
Uninational	0.65	0.50	0.44	0.47	0.47	0.50
Multinational	0.63	0.75	0.77	0.72	0.78	0.72
Average	0.57	0.53	0.50	0.48	0.47	0.51

Table 5: Number of employees, mean.

	REG 1	REG 2	REG 3	REG 4	REG 5	SWE
Non Affiliate	325	102	46	50	50	110
Uninational	587	198	157	254	151	270
Multinational	648	381	324	567	417	494
Average	504	207	142	222	145	249

[3] Innovative firms are firms reporting a product and/or process innovation and/or reporting ongoing innovation activities.

Table 6: Firm characteristics. Mean and standard deviation.

Panel A: All firms

	REG 1	REG 2	REG 3	REG 4	REG 5	SWE
Sales [1]						
-Non affiliate	4.73 (1.00)	4.72 (0.61)	4.81 (0.74)	4.77 (0.69)	4.68 (0.71)	4.74 (077)
-Uninational	5.05 (1.23)	5.03 (0.85)	5.06 (0.77)	4.96 (0.74)	5.01 (0.77)	5.02 (0.89)
-Multinational	5.33 (1.01)	5.18 (0.64)	5.32 (0.59)	5.38 (0.67)	5.27 (0.67)	5.30 (0.77)
Profit margin	0.05 (0.32)	0.06 (0.19)	0.07 (0.20)	0.05 (0.06)	0.06 (0.26)	0.06 (0.26)
Firm size, log	4.22 (1.69)	4.09 (1.46)	3.84 (1.30)	3.88 (1.40)	3.83 (1.29)	3.97 (1.44)
Newly established [2]	0.10 (0.30)	0.05 (0.22)	0.06 (0.23)	0.06 (0.24)	0.04 (0.20)	0.07 (0.25)
M&A, [2]	0.11 (0.31)	0.07 (0.26)	0.10 (0.31)	0.08 (0.29)	0.10 (0.30)	0.10 (0.30)
Human capital, share[3]	0.19 (0.21)	0.08 (0.13)	0.09 (0.13)	0.10 (0.16)	0.06 (0.10)	0.11 (0.16)
Physical capital[1]	2.06 (1.68)	2.74 (1.67)	2.78 (1.61)	2.71 (1.64)	3.06 (1.47)	2.68 (1.64)
Global market, [2]	0.25 (0.43)	0.31 (0.46)	0.32 (0.46)	0.33 (0.47)	0.26 (0.44)	0.29 (0.45)

Note: (1) In 1000 Euro, per employee, log. (2) Share of the firms. (3) Share of the employee

Panel B: Innovative firms

	REG 1	REG 2	REG 3	REG 4	REG 5	SWE
Firm size, log	4.45 (1.74)	4.51 (1.50)	4.20 (1.37)	4.33 (1.55)	4.19 (1.42)	4.33 (1.55)
Physical capital[1]	1.84 (1.66)	2.80 (1.54)	2.88 (1.53)	2.63 (1.52)	3.08 (1.55)	2.59 (1.64)
Global market[2]	0.31 (0.46)	0.44 (0.49)	0.44 (0.50)	0.40 (0.49)	0.39 (0.49)	0.38 (0.49)
Newly establishments[2]	0.09 (0.28)	0.05 (0.21)	0.07 (0.26)	0.09 (0.28)	0.03 (0.17)	0.06 (0.25)
M&A[2]	0.14 (0.35)	0.10 (0.30)	0.12 (0.32)	0.12 (0.33)	0.14 (0.35)	0.13 (0.33)
Human capital, share[3]	0.20 (0.21)	0.10 (0.14)	0.11 (0.15)	0.12 (0.17)	0.07 (0.12)	0.12 (0.17)
R&D personnel[3]	0.09 (0.18)	0.07 (0.14)	0.07 (0.20)	0.07 (0.16)	0.04 (0.09)	0.07 (0.15)
Process innovation[2]	0.55 (0.50)	0.51 (0.50)	0.51 (0.50)	0.48 (0.50)	0.49 (0.50)	0.51 (0.50)
Persistent R&D[2]	0.48 (0.50)	0.53 (0.50)	0.50 (0.50)	0.47 (0.50)	0.48 (0.50)	0.49 (0.50)
Innovation input [1]	1.36 (1.86)	1.25 (1.65)	1.03 (1.85)	1.06 (1.70)	1.00 (1.60)	1.14 (1.73)
Scientific IS collaboration[2]	0.19 (0.39)	0.29 (0.45)	0.19 (0.39)	0.25 (0.43)	0.23 (0.42)	0.23 (0.42)
Vertical IS collaboration[2]	0.27 (0.44)	0.37 (0.48)	0.25 (0.44)	0.29 (0.45)	0.31 (0.46)	0.30 (0.45)
Global collaboration on inno. [2]	0.25 (0.43)	0.30 (0.46)	0.22 (0.42)	0.23 (0.42)	0.20 (0.40)	0.24 (0.43)
Patent application[2]	0.23 (0.42)	0.38 (0.48)	0.36 (0.48)	0.33 (0.47)	0.31 (0.46)	0.31 (0.46)
Non-Imitation innovations[2]	0.39 (0.48)	0.36 (0.48)	0.31 (0.46)	0.39 (0.48)	0.35 (0.48)	0.37 (0.48)
Innovation sales[1]	2.37 (2.09)	1.84 (1.78)	2.03 (1.84)	2.14 (1.75)	1.94 (1.80)	2.08 (1.88)
Total sales[1]	5.12 (1.03)	5.01 (0.73)	5.08 (0.66)	5.02 (0.71)	5.07 (0.75)	5.07 (0.81)
Value added[1]	3.96 (0.92)	3.93 (0.88)	3.98 (0.50)	3.95 (0.53)	4.01 (0.62)	3.97 (0.72)

Note: (1) In 1000 Euro, per employee, log. (2) Share of the firms. (3) Share of the employee

REGRESSION RESULTS

Table 7: Probit parameter estimates of determinants of "innovative firm"[4]

	Coeff.	St.err.
Regions		
Stockholm	0.209**	0.094
East Central	0.073	0.098
South	0.057	0.099
West	0.107	0.088
Other Sweden	Ref	
Corp Struc		
Non Affiliate	Ref	
Uninational	0.128*	0.069
Multinational	0.435***	0.089
Firm Characteristics		
Profit margin	- 0.010	0.119
Firm size	0.166***	0.022
Physical capital per employee, log	0.064***	0.020
Human capital	0.931***	0.249
Newly established	- 0.036	0.120
M&A	0.356***	0.100
Local market	Ref	
National market	0.464***	0.073
Global market	0.785***	
Sector classification		
High technology manufacturing	0.537***	0.150
High medium technology manufacturing	0.180*	0.096
Low medium technology manufacturing	0.067	0.097
Low technology manufacturing	Ref	
Knowledge intensive service	0.075	0.122
Other services	- 0.385***	0.092

[4] Firms reporting a product and/or a process innovation and/or reporting ongoing innovation activities

Table 8: Innovation investment and collaboration on innovation.

Selection equation

Number of observations: 1,907 of which 972 uncensored observations

Equation	(1)		(2)		(3)		(4)	
	R&D and other innovation input per employee, log		Collaboration on innovation within scientific IS		Collaboration on innovation within vertical IS		Global collaboration on innovation	
	Coeff	St.err.	Coeff	St.err.	Coeff	St.err.	Coeff	St.err.
Regions								
Stockholm	0.126	0.142	- 0.474***	0.154	- 0.335**	0.142	0.000	0.137
East Central	0.208	0.153	0.079	0.149	0.127	0.144	0.174	0.140
South	- 0.022	0.155	- 0.309*	0.168	- 0.298*	0.156	- 0.108	0.152
West	0.033	0.141	- 0.046	0.144	- 0.168	0.139	- 0.036	0.137
Other Sweden	Ref		Ref		Ref		Ref	
Corp Struc								
Uninational	Ref		Ref		Ref		Ref	
Multinational D	0.842***	0.235	0.983***	0.221	1.338***	0.230	1.198***	0.225
Multinational F	0.175	0.128	0.170	0.130	0.254**	0.123	0.421***	0.125
Non Affiliate	- 0.014	0.115	0.265**	0.125	0.253**	0.117	0.326***	0.117
Knowledge								
R&D invest	-	-	0.136***	0.038	0.104***	0.094	0.170***	0.036
Persistent R&D	1.220***	0.109	0.710***	0.139	0.732***	0.103	0.624***	0.127
Characteristics								
Firm size	- 0.412***	0.039	0.204***	0.055	0.115***	0.032	0.149***	0.034
Newly establish.	- 0.097	0.215	- 0.252	0.224	0.060	0.193	0.173	0.195
M&A	- 0.274*	0.163	- 0.325**	0.153	0.024	0.145	- 0.104	0.143
Process innov	0.222**	0.095	0.201*	0.098	0.230**	0.094	0.057	0.090

Note: The following selection variables are included in equations (1)-(4): Firm size, Sales, Newly established, M&A, Physical capital, Human capital, Market orientation and six sector dummies.

Significant at the 1% (***), 5% (**) and (*) 10% level of significance. Six sector dummies are included: High technology manufacturing (HI-M), high medium technology manufacturing (HM-M), low medium technology manufacturing (LM-M), low technology manufacturing (LO-M), knowledge intensive services (KI-S) and other services (O-S).

Table 9: Innovation investment and collaboration on innovation.
Selection equation**.**
Number of observations: 1,907 of which 972 uncensored observations

Equation	(5)		(6)		(7)		(8)	
	Non-Imitation innovations		New product sales/ employee		Total sales/ employee		Value added/ employee	
	Coeff	St.err.	Coeff	St.err.	Coeff	St.err.	Coeff	St.err.
Regions								
Stockholm	0.146	0.131	0.390***	0.163	0.296***	0.080	0.135**	0.054
East Central	0.023	0.139	- 0.242	0.173	0.027	0.086	- 0.004	0.057
South	- 0.123	0.144	0.009	0.173	0.040	0.087	- 0.041	0.058
West	0.128	0.129	0.160	0.159	0.020	0.080	- 0.020	0.053
Other Sweden	Ref		Ref		Ref		Ref	
Corp Struc								
Uninational	Ref		Ref		Ref		Ref	
Multinational D	0.609***	0.210	0.688**	0.290	- 0.053	0.136	- 0.031	0.093
Multinational F	0.210*	0.118	0.520***	0.150	0.101	0.072	- 0.015	0.049
Non Affiliate	0.389***	0.106	0.232*	0.130	- 0.137**	0.064	- 0.084**	0.043
Knowledge								
R&D invest	0.031	0.030	0.131***	0.036	0.069***	0.014	0.031**	0.012
Persistent R&D	0.440***	0.110	0.273*	0.139	- 0.065	0.065	0.018	0.044
Science IS	0.333**	0.133	0.009	0.172	0.115*	0.069	0.059	0.058
Vertical IS	0.136	0.123	0.167	0.157	- 0.089	0.065	- 0.108	0.054
Global collab.	0.048	0.132	0.217	0.169	0.112*	0.067	0.076	0.057
Characteristics								
Firm size	- 0.103**	0.041	- 0.406***	0.055	- 0.043*	0.023	- 0.109***	0.017
Physical cap	- 0.029	0.032	- 0.119***	0.046	0.129***	0.016	0.161***	0.016
Newly establish.	0.181	0.174	- 0.272	0.271	- 0.309***	0.116	- 0.280***	0.095
M&A	- 0.020	0.138	0.063	0.209	0.033	0.089	- 0.279***	0.072
Process innov	0.216**	0.087	- 0.051	0.102	0.028	0.053	0.055	0.035

Note: The following selection variables are included in equations (5)-(6): Firm size, Sales, Newly established, M&A, Physical capital, Human capital, Market orientation and six sector dummies. In equations (7) and (8) all these variables are included except sales.

Significant at the <1% (***), <5%(**) and (*) <10% level of significance. Six sector dummies are included: High technology manufacturing (HI-M), high medium technology manufacturing (HM-M), low medium technology manufacturing (LM-M), low technology manufacturing (LO-M), knowledge intensive services (KI-S) and other services (O-S). (a) Reference is local market

APPENDIX

Table 10: Innovation investment and collaboration on innovation.

Robust regression
Number of observations: 972

Equation	(1)		(2)		(3)		(4)	
	R&D and other innovation input per employee, log		Collaboration on innovation within scientific IS		Collaboration on innovation within vertical IS		Global collaboration on innovation	
	Coeff	St.err.	Coeff	St.err.	Coeff	St.err.	Coeff	St.err.
Regions								
Stockholm	0.143	0.128	- 0.566***	0.171	- 0.330**	0.147	0.066	0.166
East Central	0.127	0.135	0.067	0.162	0.127	0.146	0.251	0.166
South	- 0.017	0.137	- 0.393**	0.182	- 0.313**	0.157	- 0.103	0.182
West	0.043	0.125	- 0.073	0.157	- 0.166	0.141	0.014	0.163
Other Sweden	Ref		Ref		Ref		Ref	
Corp Struc								
Uninational	Ref		Ref		Ref		Ref	
Multinational D	0.428**	0.199	1.050***	0.233	1.332***	0.230	1.308***	0.244
Multinational F	- 0.024	0.113	0.240*	0.141	0.288**	0.126	0.492***	0.138
Non Affiliate	0.065	0.103	0.335**	0.137	0.270**	0.119	0.381***	0.140
Knowledge								
R&D invest	-	-	0.105***	0.041	0.092***	0.034	0.156***	0.040
Persistent R&D	1.013***	0.085	0.790***	0.131	0.701***	0.114	0.765***	0.131
Characteristics								
Sales	0.334***	0.062	0.087	0.083	- 0.023	0.072	0.139*	0.083
Firm size	- 0.412***	0.039	0.255***	0.042	0.115***	0.032	0.141***	0.042
Newly establish.	0.083	0.171	- 0.201	0.241	0.090	0.195	0.173	0.195
M&A	- 0.030	0.127	- 0.299**	0.164	0.012	0.141	0.013	0.161
Process innov	0.184**	0.083	0.223**	0.107	0.234**	0.095	0.063	0.107
Physical capial			0.087	0.083	- 0.023	0.073	0.110**	0.043
Human capital	2.851***	0.316	1.703***	0.395	0.725**	0.357	0.919**	0.400
Local market	Ref		Ref		Ref		Ref	
National market	0.082	0.127	- 0.311*	0.181	- 0.209	0.148	0.272	0.214
Global market	0.418***	0.142	- 0.320	0.196	- 0.271	0.166	0.477***	0.222

Note: Significant at the 1% (***), 5% (**) and (*) 10% level of significance. Six sector dummies are included: High technology manufacturing (HI-M), high medium technology manufacturing (HM-M), low medium technology manufacturing (LM-M), low technology manufacturing (LO-M), knowledge intensive services (KI-S) and other services (O-S).

Table 11: Innovation investment and collaboration on innovation.
Robust regression.
Number of observations: 972

Equation	(5)		(6		(7)		(8)	
	Non-Imitation innovations		New product sales/ employee		Total sales/ employee		Value added/ employee	
	Coeff	St.err.	Coeff	St.err.	Coeff	St.err.	Coeff	St.err.
Regions								
Stockholm	0.158	0.133	0.361**	0.184	0.263***	0.054	0.151***	0.037
East Central	0.027	0.141	- 0.196	0.194	- 0.078	0.057	- 0.007	0.039
South	- 0.123	0.146	0.063	0.197	0.070	0.058	- 0.014	0.039
West	0.131	0.131	0.191	0.180	0.032	0.053	0.004	0.036
North	Ref		Ref		Ref		Ref	
Corp Struc								
Uninational	Ref		Ref		Ref		Ref	
Multinational D	0.602***	0.217	0.804***	0.297	- 0.031	0.087	0.046	0.060
Multinational F	0.205*	0.119	0.601***	0.163	0.085*	0.048	0.015	0.033
Non Affiliate	0.385***	0.108	0.263*	0.147	- 0.147**	0.043	- 0.065**	0.028
Knowledge								
R&D invest	0.031	0.030	0.172***	0.042	0.059***	0.0127	0.021**	0.008
Persistent R&D	0.440***	0.108	0.442***	0.149	0.001	0.043	0.039	0.030
Science IS	0.345**	0.135	0.024	0.192	0.089	0.056	0.064	0.038
Vertical IS	0.139	0.124	0.265	0.176	- 0.074	0.051	- 0.047	0.035
Global collab.	0.043	0.134	0.230	0.189	0.016	0.055	0.052	0.038
Characteristics								
Firm size	- 0.090**	0.035	- 0.168***	0.047	0.002	0.014	- 0.007	0.009
Physical cap	- 0.026	0.033	- 0.109**	0.044	0.159***	0.013	0.158***	0.009
Newly establish.	0.182	0.175	- 0.323	0.246	- 0.106	0.072	- 0.134***	0.049
M&A	0.009	0.134	0.436**	0.183	0.092*	0.053	- 0.012	0.037
Process innov	0.214**	0.088	0.068	0.121	- 0.012	0.035	- 0.000	0.024
Human capital	- 0.015	0.341	0.342**	0.138	0.342**	0.138	0.462***	0.095
Local market	Ref		Ref		Ref		Ref	
National market	0.076	0.135	0.119**	0.053	0.119**	0.053	0.009	0.036
Global market	0.147	0.151	0.264***	0.060	0.264***	0.060	0.035	0.041

Note:. Significant at the 1% (***), 5% (**) and (*) 10% level of significance. Six sector dummies are included: High technology manufacturing (HI-M), high medium technology manufacturing (HM-M), low medium technology manufacturing (LM-M), low technology manufacturing (LO-M), knowledge intensive services (KI-S) and other services (O-S).