45th Congress of the European Regional Science Association
Amsterdam, Netherlands

The Innovativeness of the Finnish High Technology Firms – The Role of Internal Factors, Cooperation and the Mobility of Labour

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Abstract

Innovation is the driving force of the economy and it is the most important factor to the competitiveness of firms. Firms' capability to innovate, introduce new products to the market and develop new production methods has a significant effect on their success in the domestic and international markets. The role of innovativeness is emphasised particularly in the industries with a high growth rate and rapidly developing technology.

This paper investigates the innovativeness of Finnish high technology firms, more precisely their local business units, between 1996 and 2002. Innovativeness of local business units is measured in terms of their ability to introduce both product and process innovations. The role of internal and external factors on the innovativeness of local units is analysed by the means of the probit analysis. An important and novel feature of my paper is that our data provides a unique chance to evaluate the role of two important channels of technological diffusion, R & D cooperation between the firms and institutions and the inter-firm mobility of labour for the innovativeness of high technology establishments.

Econometric results reveal that internal factors of local units affect their ability to introduce product and process innovations differently. I find evidence that R & D cooperation, both between firms and between firms and research institutions, can act as a significant catalyst for innovation activity. Moreover, our empirical findings give some evidence that worker inflows, and thereby technology diffusion from other firms, has an effect on the innovativeness of the high technology establishments.

Keywords: Innovativeness, High technology, R & D cooperation, Labour mobility

JEL classification: O310, R300

1. The introduction

Innovation is the driving force of the economy and the innovativeness is the most important factor to the competitiveness of firms. Firms' capability to innovate, introduce new products to the market and develop new production methods has a significant effect on their success in the domestic and international markets. The role of innovativeness is emphasised particularly in the industries with a high growth rate and rapidly developing technology. In these fields of industries firms' capability to learn and create as well as absorb and appropriate new knowledge from their environment has the central role. A consequence has been that innovativeness of firms has risen to centre stage of industrial policy in several ways.

After Schumpeter (1934, 1942), most of the theoretical and empirical literature has been motivated by the idea that monopoly power and large firm size has a positive impact on innovation.[1] However, in most theories and studies of innovation the starting-point is that the firms' own R & D -intensity is the most important factor in generating new innovations and technology (Audretsch 1998, Arrow 1962). Firms invest in R & D to discover new knowledge and to generate new innovations. R & D investments has also another role which increases firm's incentive to invest in R & D. Growing body of empirical evidence strongly support the view that R & D increases firm's 'absorptive capacity' (Cohen and Levithal 1989). Firms which have invested a lot on R & D are not only more innovative but they have also better chances to adopt and appropriate the knowledge and ideas developed by other firms.

Nowadays many firms, instead of relying completely on their own R & D efforts, choose broad R & D orientation considering external knowledge sources. (Dachs et al. 2004) Firms' attempt to learn and create as well as absorb and appropriate new knowledge have, together with the capacity constraints, forced firms to an active co-operation with other firms and institutions, e.g. universities and research centres. In knowledge-intensive economy co-operation between the firms has clearly become deeper including R & D activities, where firms exchange highly confidential information about the latest technology.

A number of studies have also argued that active co-operation between the firms and institutions form the significant channel for technological diffusion (Katz 1986). The active R & D co-operation with external partners helps firms' ability to react rapidly to changes in their business and technological environment. Labour mobility forms another important mechanism through which knowledge diffuses (Breschi and Lissoni 2001b). The mobility of

[1] Many studies have analysed directly the impact of firm size or market structure on innovation. Particularly in the 1960s and 1970s numerous of studies, using different measures of innovative activity and research methods, were conducted to study the relationship between innovative activity and firm size (Cohen and Klepper, 1996a). owever, there is a wide variety of studies which have tested a number of specific hypotheses as to why a positive effect may exist (Symeonidis, 1996).

labour between the firms and institutions provides a channel for knowledge and ideas to diffuse within and across regions and industries.

In this paper we utilise empirical data from Finland in order to analyse the importance of the internal factors of the high technology establishment, their cooperation relationships with various external partners and the mobility of labour between the establishments of firms and institutions, both within and across the regions and industries, on the innovation performance of the Finnish high technology establishments. The most important novelty of this paper is that our data provides a unique chance to evaluate, after controlling the internal factors of establishments, the role of two important channel of technological diffusion, R & D cooperation between the firms and institution and the inter-firm mobility of labour, for the innovativeness of high technology establishments.

The paper is organised as follows. In section 2 we review the various hypotheses which exist in the literature concerning the relationship between innovation and internal and external factors of firms. Section 3 gives some descriptive features of our dataset. An econometric analysis of the innovative behaviour is presented in section 4. Section 5 provides some brief conclusions.

2. Theoretical background and the review of empirical literature

Since Schumpeter (1942) the relationship between the innovation and the firm size, i.e. how firm size is related to the ability and propensity to innovate, has been probably the most studied issue in the literature.[2] However, the conclusions from past empirical researches are far form consistent. Some studies favour a large size, some small size, and some both small and large size at the same time. The question is interesting, because there are obvious policy implications of this relationship. For example, the notion that large firms and market concentration are conducive to a faster rate of innovation has been used to justify industrial policies of support for "national champions" through R & D subsidies (Symeonidis 1996).

Over the past few decades, at least following factors favouring the innovative advantage of large enterprises have been identified in the literature. First, innovative activity involves high fixed costs and these can only be covered if sales are sufficiently large (Sherer 1984, Cohen et al. 1987). Secondly, large diversified firms are in better position to appropriate the economic returns from unforeseen innovations (Kamien and Schwartz 1982, Cohen and Levin 1989). Thirdly, large firms can reduce the risk accompanying innovation through diversification into simultaneous research projects (Rothwell and Zegveld 1982).

[2] Schumpeter argued that large firms operating in a concentrated market exploiting their market power are the main engine of technological growth. (Acs 2002) According to Cohen and Levin (1989) these hypothesis have given rise to the second largest body of empirical literature in the field of industrial organisation. Symeonidis (1996) provides the review of the large empirical literature on links between innovation, market structure and firms size. See also Acs (2002), Galende and de la Fuente (2003) and Kamien and Schwartz (1982).

Moreover, there are scale and scope economies in production in innovations (Acs and Audretcsh 1990) and an innovation yielding cost reductions of a given percentage results in higher profit margins for larger firms than for smaller firms (Acs 2002). Large firms have also better access to external finance (Acs 2002). Furthermore, in concentrated industries firms with large market share have easier to finance R & D from own profits[3], and they can more easily appropriate the returns from innovation (Symeonidis 1996). [4]

Recently some studies have challenged this conventional 'Schumpeterian' wisdom (Acs 2002). Just as there is a persuasive defence of the original Schumpeterian hypothesis that large firms are a prerequisite for technological change, the substantial counterarguments have been presented that small firms could have the innovative advantage, at least in certain industries (Kamien and Schwartz 1982).[5] Most frequently invoked counterarguments against Shumpeterian view is the existence of decreasing returns to scale in the production of innovations due to loss of managerial control (Rothwell 1989) and the bureaucratisation of innovative activity (Sherer 1991). Large firms are too bureaucratic organisation and less flexible to undertake risky R & D. Small and medium size firms instead are more flexible and less bureaucratic organisations and thereby they are able to react quickly and efficiently to both market and technological changes (Acs 2002, Karlsson and Olsson 1998, Link and Bozeman 1991).[6]

The question of how firm-size relates to the ability and propensity to innovate is probably one of the oldest in the literature of political economy and industrial organisation. However, in most theories and studies of innovation the starting-point is that the firms' own R & D -activity is the most important factor in generating new innovations and technology (Audretsch 1998, Arrow 1962). Firms invest in R & D to discover new knowledge and to generate new innovations. Successful innovations are the result of trials and errors and many times it takes years or even decades of work to discover new innovation.

In academic circles, however, a broad and equally enduring consensus emerged a long time ago that economies of scale in R & D expenditure are rarely reflected in innovation output, i.e. there is no advantage to large firms in conducting R & D (Cohen and Klepper

[3] The hypothesis is that firms with large cash flow are less constrained to spend more on R & D and thereby they are more innovative. This argument has provided rationale for examining the relationship between cash flow and innovative activity, i.e. Schumpeterian view of cash flow constraining innovation (Symeonidis 1996). Oakey et al. (1988) have studied the financial resources of high technology small firms in South-East England, Scotland and the San Francisco Bay area. Their major finding was that more than two thirds of the firms in each region relied on own profits as the main source of investment finance.

[4] Since Schumpeter (1942), it has been argued that the patent system and other appropriation mechanism provides large firms with great market power better chances to appropriate the returns from innovations. However, there is a very little evidence on this.

[5] Actually there is a little empirical evidence which would support the Schumpeterian hypothesis that market power and large firms stimulate innovations (Symeonidis 1996). In some industries, the large firms may have an innovative advantage, while in other industries the small firms are apparently more innovative. (Acs 2002).

[6] Firstly, in small firms there are relatively few people who make the decision to innovate, and secondly, communication among people is generally faster and more efficient in SMEs.

1996, Kamien and Schwartz 1982, Acs and Audretsch 1991). However, the growing body of empirical evidence strongly support the view that R & D increases a firm's "absorptive capacity" (its ability to absorb technological spillovers from other firms) as well as contributing directly to profitability (Leahy and Neary 2003).[7] Highly intensive R & D firms, i.e. firms which have invested a lot on R & D, are not only more innovative but they have also better chances to adopt and appropriate the knowledge and ideas developed by other firms, i.e. to identify, assimilate, and exploit knowledge which is external to firm.[8]

Accordingly, the argument is that R & D has dual role. It is undertaken to generate innovations and to increase the firm's absorptive capacity (Cohen and Levinthal 1989, Karlsson and Olsson 1998). Absorptive capacity does not only include a firm's ability to imitate new process and product innovations, but also ability to exploit the knowledge of basic research, which in turn provides the basis for subsequent applied research and development. This means that absorptive capacity presents also an important part of a firm's ability to create new knowledge (Arrow 1962, Cohen and Levinthal, 1989).[9]

R & D projects often require large fixed cost and therefore they are difficult to carry out in small firms. They expected sales are not large enough to allow them to cover these costs. In some industries, the cost of the R & D project can be so large that even large firms find it difficult to conduct independent R & D (Cohen and Klepper 1996a).[10] Despite the arguments that R & D costs varies across industries and possible also with the same industry, we may assume that in the high technology industries R & D costs are relatively large in general and thereby there exist positive relationship between the innovation output, R & D expenditures and the sales.[11]

The argument that the innovation intensity of small firms (with no or only little R & D) can be greater than that of large firms, raises the question; where do these, in most cases small firms get their knowledge inputs. A well-known idea in the literature is that research

[7] The importance of absorptive capacity has been confirmed e.g. by Cohen and Levinthal, (1989), Griffith, Redding and Van Reenen (2000) and Girma (2003). Leahy and Neary (2003) provide theoretical study about the same issue.

[8] See e.g. Cohen and Levinthal, (1989, 1990) and Audretsch (1998).

[9] Before Cohen & Levinthal published their highly quoted paper " *Innovation and learning: two faces of R & D*" in 1989, had the role of R & D, which it plays in learning received only a little attention in economic literature. In their paper, they argue that economists, who in that time suggest that technological knowledge in a public good, are wrong in saying that costs related to technology transfer and imitation are much smaller than the cost of creating new technology. According to Cohen and Levinthal (1989), when firm invests in R & D activity, they invest their absorptive capacity at the same time. In that sense exercise of absorptive capacity represents a sort of learning that differs from learning-by-doing.

[10] This argument is based on the empirical evidence that firms mainly exploit their innovations through their own output and that current firm size limits firm growth.

[11] According to Symeonidis (1996), cost of the R & D project is itself partly endogenous, since it is affect by the past and possible also the current strategic choices of firms. However, Symeonidis argues that, at any given point in time R & D costs cannot be lower than a certain minimum level, which is taken as exogenous by the firms. Cohen and Klepper (1996b) have studied the effect of firm size on the allocation of R & D effort between product and process innovations.

laboratories of universities provide a source of innovation generating knowledge that is available to private enterprises for commercial exploitation (Jaffe 1986, 1989). The knowledge created in their laboratories spills over to contribute the generation of new innovations by private firms. Technological spillovers are supposed to be particularly important source for generating innovation in small firms (Acs 2002). Another possible answer could be co-operation intensity of the small firms. In those industries were costs of R & D projects are high, the disadvantage of small firms size can be overcome through co-operative R & D agreements. The co-operation with other firms allows spreading R & D costs among other small firms.[12]

In the mid 1960s there was an intense debate on whether innovations were mainly caused by science-push' or 'demand-pull'. When first view emphasized advanced suppliers as an essential sources of new ideas, second view highlight the importance of the demanding customer and users in the innovation process. Proponents of science-push were initially inspired by the studies of Schumpeter (1942, 1934) (Karlsson and Olsson 1998). According to Schumpeter, scientific and technological advances are the most important determinants of product development. The second view, so called demand-pull view is usually considered to originate from Schmookler (1966). He concluded that market growth and market potential were the main determinants of innovative activities. Today there are supporters of both views. However, nowadays it has been recognized that focus on supply, on demand side, or on the firm itself is not sufficient to explain the complex nature of innovation adaptation.

Since the early 1990's the network view has become more and more popular approach to explain the success of the innovative activity of firms (Håkansson 1989). Traditional theories where competition and market power are the key concepts are (partly) replaced by the view that innovation activity is better explained by the collaborating of actors in the network. Innovation network of firms consists not only of links with customer and suppliers, but also of links with different intermediaries, e.g. consultants, fairs and exhibitions, universities and R & D institutes. Knowledge exchange and learning processes between these actors provides important information and technological know-how for firms and improves their competitiveness (Dachs et al. 2004).[13]

Recent empirical and historical studies have demonstrated superior innovation performance of cooperation companies.[14] Nowadays, when the whole technological environment within which firms operate has become more and more complex and the speed of knowledge generation and utilisation process has become faster, firms (especially small

[12] With exception of few studies, this is an issue which have not been widely studied in the literature on co-operative R & D.

[13] This field of study has attracted researchers of business and regional economics, as well as sociologist and geographers.

[14] See e.g. Gemunden et al. 1992, Palmberg et al. 1999, Czarnitzki and Fier 2003.

firms) are highly dependent on external sources of technology.[15] The consequence has been a restructuring of the organisation of technological activities and the growth of inter-firm technological agreements and co-operation relationships, especially in high technology sectors. Technological activities appear to be undertaken more and more through external linkages instead of intramural R & D. (Rocha 1997, Chesnais 1988, Hagedoorn and Schakenraad 1990)

Research shows that big firms have also been touched by "declining technical self-sufficiency" (Fusfeld 1986). They have had to admit that they cannot handle the development of new technology by themselves. The role of networking is emphasized in those industries, which are in that phase of product life-cycle when innovation is incremental (Karlsson and Olsson 1998). New technological challenges (cross-fertilisation of technologies, shorter product cycles and faster rates of technological change in general) have forced them to be engaged in co-operation with other firms (Bougrain and Haudeville 2002, Mowery and Rosenberg 1989, Rocha 1997).

Another crucial factor for a successful product and process development is the firm's access to labour with the required skills (Karlsson and Olsson 1998, Karlsson 1988).[16] Much of the knowledge (i.e. human capital) necessary for innovations is of a tacit kind, highly embodied in skills and experience of workers (Angel 1991). The output of innovative activity of firms is the result of their effort to appropriate this 'tacit knowledge' (Audretsch 1995, 1998). The improvements of product and process quality can only be achieved by use of qualified labour and their knowledge (Persson 2002).

This knowledge, although firms try to prevent it, spills over to other firms. Mobility of skilled labour between the firms forms probably one of the most important channels for technological diffusion. According to Almeida and Kogut (1999) (by examination the mobility paths of patent-holders) and Angel (1991) (by studying the results of survey of firms in the semiconductor industry), the high intra-regional (inter-firm) mobility of labour has promoted the local transfer of knowledge and thereby contributed significantly to the innovativeness of firms in Silicon Valley. Active local labour market network does not only increase regional supply of tacit and non-standardised knowledge, but also creates links between firms and institutions (Power and Lundmark 2004).[17] The mobility of labour increases common pool of knowledge which enhances all firms in their innovative activity.

[15] According to Chesnais (1988) and Hagedoorn and Schakenraad (1990) the number of technological agreements between the firms grow significantly during the 1980's. See also Rocha (1997).

[16] Despite the large literature related to the access of skilled labour as an important determinant of the agglomeration of high technology firms, there has been done very little analysis of the contribution of labour mobility to the success and growth of firms, and even much less, to their innovativeness.

[17] See also Saxenian 1994, Rogers and Larsen 1984, Kogut and Zander, 1994, Zander and Kogut 1995, Breschi & Lissoni 2001b.

Not only the innovation activity of firms which employ new skilled workers but also firms where these people have previously worked (Breschi and Lissoni 2001b).[18]

The localised labour mobility may also cause instability and tensions to the local collaboration of competing firms and networks, and vitiate firms' attempts to achieve competitive advantage through innovation projects. Secondly, intensive intra-regional inter-firm worker mobility may break up existing research teams and lead dissipation of resources among many competing firms. Especially during the periods of labour shortage, high turnover among workers and the loss of individual highly-skilled personnel to competing firms can have a damaging effect upon the innovation activity of firms. (Angel 1991)

Although the degree of inter-firm mobility of labour is (probably) higher in regional clusters like Silicon Valley, we have no reasons to believe that the extent or the significance of technology diffusion through labour mobility would be geographically bounded. As a matter of fact, we can well argue that inter-regional mobility of skilled workers can, in some circumstances, form equally or even more important channel of technological diffusion than intra-regional mobility of labour.[19]

3. Data description

The establishment-level data used for this research comes from innovation surveys conducted by Statistics of Finland in 1996, 2000 and 2002. The innovation surveys undertaken by Statistics Finland are conducted using subject approach, which is in the line with the Community Innovation Survey (CIS) framework. These surveys collect information about an individual establishment's innovation output defined as the launching new or significantly-improved products or processes during the previous two years. In addition to the innovation outputs, innovation surveys provide information about the firms' innovation cooperation with other enterprises or institutions.

These innovation databases have been further expanded with information from R & D Surveys and Business Register for 1990-2002. The combined database includes establishment-level information regarding each of the types of innovations exhibited by an establishment, the cooperation behaviour, the employment size of each establishment, R & D expenditures of the establishment, and the turnover of each establishment. The data about the mobility of labour between the firms and institutions, both within and across sub-regions are

[18] This argument is based on the idea that as workers move form one firm to another and start work there, they will appropriate the knowledge which they have learned in previous jobs. Thereby they will create a common pool of knowledge, which is more or less common to all their previous employers (Breschi and Lissoni, 2001b). According to Breschi and Lissoni (2001b), labor mobility generates "pure technological spillovers" if and only if worker who moves form one firm to another does not only shift knowledge from one place to another, but also spreads it to his or her all previous employers.

[19] As a matter of fact, there are some indirect proofs that in some cases firms would have made agreements which do not allow recruiting of skilled labour from other local firms. (Breschi and Lissoni 2001a, 2001b)

obtained from Finnish longitudal employer-employee (FLEED) database maintained by Statistics Finland. Our data comprises all of all the Finnish high-technology, defined according to the 1995 SIC and listed in table 1, which were included in the three innovation surveys.

Table 1: High technology industries in the manufacturing and service sectors (SIC 1995).

Manufacturing sector	**(SIC 95)**
• Manufacture of pharmaceuticals, medicinal chemicals and botanical products	(244)
• Manufacture of office machines and computers	(30)
• Manufacture radio, television, communications equipment and apparatus	(32)
• Manufacture of aircraft and spacecraft	(353)
Service sector	**(SIC 95)**
• Telecommunications	(642)
• Computer and related activities	(72)
• Research & Development	(73)
• Architectural and engineering activities and related technical consultancy	(742)

There are two research traditions based on the identification of innovative outputs - the subjective approach and objective approach. The object base approach begins by identifying the innovations themselves.[20] In the most cases innovativeness of the countries, regions, industries and single firms are measured in the number of patents.[21] Our research uses subject approach method. The subject base approach begins by identifying firms and asking them about their innovative activities. Questions of the innovation surveys enquires whether firms have introduced new product or process innovations which are new to the firm (not necessarily new to the market) and has they managed to introduce new products to the market. The definition of innovation used in the innovation surveys is much border and it gives much wider picture about the innovation activity of firms than is employed in patent citation (Jaffe et al. 1993) and R & D literature (Acs 2002) (Gordon and McCann 2005).

The innovation surveys undertaken by statistics of Finland have, like almost all innovation surveys, one major drawback, the lack of regional dimension. In surveys the status of innovative are given to whole enterprises, which means that it does not provide us real information about the innovativeness of the individual establishments. Therefore, to be able

[20] Tether (1998) provides a good review of studies based on object-based data-sets of innovative outputs in so far as they relate to the debate on firm-size and innovation.

[21] However, we may argue that patents are a flawed measure of innovative output since all innovations are not patented, all inventions are not technically patentable (e.g. software), and since patents differ greatly in their economic and technological impact (Pakes and Griliches 1980, Acs 2002). Furthermore, we may also assume that in most of the cases new patents are registered into the headquarters of corporations. This undervalues the importance of other branches of firms in their ability to generate new innovations, and thereby distorts the geographical scope of innovation activity. Another largely used index to measure the innovative output in objective approaches is the number of number of new product announcements (Wakasugi and Koyata 1997).

analyse the regional dimensions of the innovative activity we must regionalise the results of the innovation surveys.

The basic establishment-level unit of analysis is the 'local unit' (LU), and the innovation behaviour we ascribe to the local units comes from the firm level innovation data.[22] Assigning innovation behaviour to the local unit is straightforward in the single plant or single site firm because the firm is the local unit. In a case of a multi-plant firm, which has establishment in different areas, we make following two assumptions. First, in the absence of any additional information, we assume that all local units of the enterprise are engaged in the innovation activity.[23] If we assume that information is transferred effectively between different local units within the same firms (Orlando 2000), then it is appropriate to give same innovation status to all the individual local units of the same firm.[24] Thereby the innovation behaviour we ascribe to each establishment is that of the multi-plant firm as a whole. In the case of Finnish data this technique has already been previously adopted elsewhere (Alanen et al. 2000).

The innovation survey also provides information about the interaction between individual firms and institutions, which is provided at the level of the firm. As with the assignment of the innovative data, in the absence of any additional information, we assign the same levels of cooperation and interaction to each establishment within the same firms. In a case when firm has only one local unit, this straightforward. In a case of multi-plant firms, it is possible that all local units of firms do not interact with other firms and institutions to same extent. However, once again, if we assume that information and knowledge received form interactions with other firms and institutions is transferred effectively between the different local units within the same firms, it is appropriate to give same cooperation status to all the individual local units of the same firm.[25]

Table 2 shows how local units have managed to produce new product innovation, new process innovations and new, significantly improved products to the market in 2000. There are some interesting features in table 2. The most obvious feature is the high innovation intensity of small establishment employing less than 10 people. The second interesting feature is the same j-shaped relationship between the size and innovation intensity that Tether et al.

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[22] The local unit contains all business units of the firm within a same municipality. In 88 % of all local units in our data were only one establishment in 2000. So in practise our data can be considered as an establishment level data. In the case of the multi-plant local unit, the branch of the local unit is determined according to that establishment which employs the largest share of employees in that local unit in question.

[23] Although the research centre of the enterprise has the most important role in innovation activity in most of the cases, innovations can result from needs of production or other non-research units as well. Furthermore, we may assume that innovations are result of the intensive co-operation and interaction between several, if not all units of enterprises.

[24] The vast majority of the surveyed firms had less than three establishments and almost half had only one establishment.

[25] In other words, we expect firms to act to maximize spillovers among their own plants, in a same time as they try to minimize inter-firm spillovers (Orlando 2000).

(1997) found in their research.[26] The innovativeness of small local establishments (1-9 employees) is proportionally larger than the innovativeness of their larger counterparts, LUs employing 10-49, or even 50-99 people. Although we have not use exactly the same method as they did, our findings support the idea that small firms and establishments are important sources of new innovations.

Table 2: The Percentage share of local units engaging in each type of innovation (2000 Survey)

Size of the Local Unit (number of employees)	**% of Local Units Producing Product Innovations**	**% of Local Units Producing Process Innovations**	**% of Local Units Producing New Products to Market**
1 – 9	75.92	56.33	64.08
10 - 19	63.50	30.66	54.01
20 - 49	65.11	41.09	57.36
50 - 99	76.74	44.19	62.79
100 - 249	77.78	60.32	66.67
250 +	87.80	73.13	80.49
Total	72.19	48.63	61.40

4. The analysis

We estimate a Probit regression-model to analyse the factors behind the successful innovation activity of the high technology establishments. The binary dependent variable, result of the innovative process, attains the value 1 if local unit has managed to introduce new innovations and value 0 otherwise. We estimate separate probit models for all types of innovations, i.e. product and process innovations as well as new product innovations to the market.[27]

Previous empirical studies have investigated a wide number of potential variables that might be linked to a firm's propensity to innovate (Harris et al. 2001, Symeonidis 1996). We will concentrate on studying the effects of the following variables suggested by the literature. Our set of explanatory variables includes zero-one dummy variables dum_1 , . . . , dum_6 for the levels of a categorized version of the number of employees in the local establishment, continuous variables for establishment turnover and lagged R & D expenditures of the establishment, and a dummy variable indicating whether the establishment has co-operated with other firms or institutions.[28]

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[26] Tether et al. (1997) found out that small enterprises did not introduce a disproportionately large share of innovations relatively to their share of employment, and only the largest enterprises introduced more innovation than their size would imply. Furthermore, they argue that if the value of innovations tends to increase with the size of innovator, then the distribution of innovative intensities would be even more distinctly j-shaped.

[27] The dataset includes the firms which have introduced new innovations or they have had activities to develop or introduce new product and process innovations (including any R & D activity), which are either abandoned or not yet completed.

[28] Dataset now includes those establishments, of which turnover and R & D expenditures were positive and which employed at least 1 employee in current or previous period. We made these restrictions to be able to analyse the innovativeness of the establishments which have already stabilised their business activities.

We study the effects of the explanatory variables listed above on the LU's propensity to innovate within the framework of the following probit model:

$$P(Y_i = 1 \mid X) = \Phi(\beta'X_i) , \qquad Y_i \text{ independent of } Y_j \text{ when } i \neq j , \quad i = 1,\dots,n$$

$$\Leftrightarrow$$

$$\Phi^{-1} (P(Y_i = 1 \mid X_i)) = \beta'X_i = \beta_0 + \beta_1 \log (\text{turnover}_i) + \beta_2 \log (\text{R \& D expenditures}_i , \text{lagged}) + \beta_4 \text{ Cooperation}_i + \beta_5 \text{ dum}_1 (\text{\# empl. in LU}_i) + \dots + \beta_{10} \text{ dum}_6 (\text{\# empl. in LU}_i)$$

where Φ denotes the cumulative distribution function of the standard normal distribution and its inverse Φ^{-1} (the so-called probit function) serves as the link function. The value of the dependent variable of the i^{th} observation is denoted by Y_i , X_i denotes the vector of independent variables for the i^{th} observation and β is the vector of parameters.

The arguments presented in section 2 leads us to pose the following hypotheses;

H1: Smaller size of the local units in terms of the employees increases innovativeness.

"The small units are more innovative because of they are less bureaucratic organizations and thereby there exist less bureaucratic resistance and constraints to undertake risky."

H2: Greater size of the local units in terms of the turnover increases innovativeness.

"Innovative activity requires high fixed costs and thereby it can be carried on only by a firm that has the resources which are associated with considerable size."

H3: The investments on R & D (during the previous periods) promote firms' ability to generate new innovations.

"Firms invest in R & D not only to pursue directly new process and product innovation, but also to develop and maintain their broader capabilities to assimilate and exploit externally available information (Cohen and Levinthal 1989)."

H4: The co-operation of local units with external partners (other firms and institutions) promotes innovativeness.

"*The co-operation with other firms and institutions reinforces firms' innovativeness by providing them with a window on technological change, sources of technological assistance, market requirements and strategic choices made by other firms. Furthermore co-operation relationships and networks are also potential channels of tacit knowledge and they reduce uncertainty related to innovation process* (Bougrain and Haudeville 2002)."

The results of our estimations (reported in table 3) shows that all our variables, i.e. the categories of LU (measured by the employment), the size of the turnover (in logarithmic scale), R & D expenditures in previous period (in logarithmic scale) and co-operation with other firms and institutions has an own role in the innovation process, especially in a case of product innovations.[29] In a case of product innovations (model 1 in table 3), all variables in the model are significant at the level of 5 %. Empirical evidence provides broad support for second, third and forth hypothesis, i.e. higher turnover, higher R & D expenditures (in previous period) and co-operation with external partners increases the probability of establishments to introduce new product innovations. However, in a case of product innovations, the employment size of the establishment plays no statistically significant role relatively to the baseline category of the very large establishments.[30]

These results of the model 1 presented in table 3 support the general idea that firms with large cash flows are less constrained to spend more on R & D, everything else being equal, and therefore they are more innovative. Furthermore, results that R & D investment has a positive on innovation propensity implies that highly intensive R & D firms have probably better chances to adopt and appropriate the knowledge and ideas developed by other firms also.[31]

In the case of introducing process innovations, the size of the turnover or R & D expenditures appear to play no role.[32] This supports the idea, that introducing of process innovations do not necessarily require high investment on R & D. Process innovations are probably more or less result of the occasional business activity and "learning-by-doing"-processes than the R & D activity itself. The results suggest, however, that or very large establishments employing over 250 people (as well as very small establishments employing less than 10 people) are statistically more likely to exhibit process innovations than the LUs employing between 10-249 employees. This indicates that large establishments are probably more cost awareness and desire to reduce production costs than their smaller counterparts.[33]

We can also say that the employment size of the LU plays statistically significant role in the process of the introducing entirely new products to the market. We find some evidence that smaller size of LU in term of employees would increase probability to produce

[29] The Probit models that we have used are additive separate. In other words we can study the role of one variable after we have taken care of the effects of other variables. It may be mentioned that we did not find any significant differences whether we used probit or logit estimation procedures.

[30] When we merged three biggest categories of size into one category in model 1, we found weak evidence that smaller size in terms of employees would increase establishment's probability to innovate. In models 2 and 3 in table 3 this modification did not cause significant changes.

[31] Our result is the parallel with findings of Rouvinen (2002), for instance. Rouvinen (2002) studies the characteristics of product and process innovators among Finnish manufacturing firms with data from the 1996 Community Innovation Survey.

[32] Our result is again the parallel with findings of Rouvinen (2002). Dachs et al. (2004), Gordon and McCann (2005) and Harris et al. (2001), for instance, have presented opposite findings. However, it is difficult to compare these studies to each other because the target group and set of variables which have been used in these studies are different.

[33] Firms' attempt to produce process innovations reveal strong cost awareness, since process innovation primarily yield productivity gains by reducing production costs. This means that when price competition becomes fierce, large units particularly can face high pressure to cut their costs (Palmberg et al. 1999).

innovations, although in this case innovation performance is once again also related to the lagged values of R & D expenditure.

Table 3: The Probit Model: Likelihood of Introducing of New Innovation
(Pooled data for years 1996, 2000 and 2002)

Dependent variable (0,1)	**The introducing of product innovation**		**The introducing of process innovation**		**The introducing of the new products to the market**	
The name of the explanatory variables	**the coefficient Model 1** (p-values in parenthesis)		**the coefficient Model 2** (p-values in parenthesis)		**the coefficient Model 3** (p-values in parenthesis)	
Intercept /Constant	-2.1280*	(0.0613)	0.0575	(0.9562)	-2.7047***	(0.0138)
Categories of LUs						
very small LUs (1-9)	0.6757*	(0.1021)	- 0.5018	(0.1804)	0.9045**	(0.0190)
small LUs (10-19)	0.2723	(0.4443)	- 0.8740***	(0.0071)	0.5222	(0.1134)
SMLUs (20-49)	- 0.0216	(0.9477)	- 0.9112***	(0.0023)	0.3566	(0.2368)
SMLUs (50-99)	- 0.2709	(0.4091)	- 0.6377**	(0.0292)	0.2051	(0.4886)
SMLUs (100-249)	- 0.2117	(0.4855)	- 0.4428*	(0.0794)	0.4610*	(0.0873)
Large LUs (250→)	0.0000	*Reference category*	0.0000	*Reference category*	0.0000	*Reference category*
Log Turnover	0.1492***	(0.0039)	0.0613	(0.1962)	0.0711	(0.1566)
Log R&D expenditures (1 year lag)	0.0756**	(0.0573)	- 0.0243	(0.5140)	0.1421***	(0.0003)
Cooperation	1.3721***	(<.0001)	0.9912***	(<.0001)	0.7590***	(<.0001)
n	699		630		579	
(Log-likelihood	*-315.5551*		*-367.8758*		*-333.3488*	*)*
LR statistics	χ^2	p - value	χ^2	p - value	χ^2	p - value
Categories of LUs	17.15	0.0042	21.70	0.0006	11.06	0.0503
Turnover	8.38	0.0038	1.69	0.1940	2.01	0.1563
R & D expenditures	3.63	0.0568	0.43	0.5140	13.16	0.0003
Cooperation	144.18	<.0001	61.21	<.0001	34.58	<.0001

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

The important result is that for all three types of innovation, the one consistently coefficient estimate is positive estimate for the cooperation variable. This implies that for all three types of innovation, after controlling for the various scale effects, the probability of innovation is increased if individual establishment cooperates with other establishments or institutions. Our results confirm the idea that R & D co-operation with other firms and institutions is likely to spur innovation of the high technology firms.

In conclusion, the results of table 3 clearly show that particularly in the case of product innovations and new products to the markets, both internal R & D and R & D co-operation with external partners seem to have a significant, positive effect on the innovativeness of the high technology establishments. Furthermore, larger is the size of the LU in terms of employees, more likely it is to exhibit process innovations.[34]

Co-operation with different types of partners

When we look at how co-operation with different partners affects innovativeness, the results are in line with our earlier findings in several ways (Table 4).[35] The methodology that have used takes into account the possibility that the innovativeness of local units depends not only on the category of the size (in terms of the number of employees), the size of the turnover, the R & D expenditures in previous year, but also on their R & D cooperation with different type of external partners, e.g. with customers, suppliers, competitors etc.

Results reported in table 4 give support to the hypothesis 1 in a case of product innovation and new products to the market. Smaller size of the LU in terms of the employees seems to increase LU's probabilities to innovate.[36] Furthermore, in case of product innovations, the establishments with higher turnover are more likely to exhibit innovations. As before, large units it terms of employees seem to be more efficient to introduce process innovations. The results confirm the idea that the higher turnover as such does not necessarily provide better opportunities to introduce process innovations, i.e. to improve production technology or introduce new and significantly improved methods of supplying services and of delivering products.

The interpretation of the results concerning the of R & D expenditure are somewhat confusing. In a case of process innovation, R & D expenditures seem to have a statistically negative effect on innovativeness. Both in the cases of product innovation and new products to markets, R & D variable are insignificant.[37]

What it comes to the collaboration with external partners, the coefficient estimate that is consistently significant for all types of innovations, is the positive estimate for the cooperation within the enterprise group. This implies that, again after controlling for various scale effects, the cooperation within the enterprise group increases significantly the probability of all types of innovation. This indicates that multi-plant firms are more likely to

[34] To get more reliable picture about the effects of the R & D expenditure on innovativeness, we also estimated, by using the GEE (generalized estimating equations) estimation procedure (Diggle et al. 1994, Ch. 7), a number of models where we used different values of for the establishment and firm level R & D expenditures (also per employees) and by employing both a one year lag and also the sum of two previous years. The results of the GEE-estimations support our conclusions.

[35] The sample sizes are now much smaller because not all firms in the sample provided data about their cooperation relationships with different type of partners and because the 2002 survey contained no information on that particular issue.

[36] Our findings are in the line with e.g. Rouvinen (2002).

[37] However, if we keep variables of category of size, the turnover and R & D expenditures in models whether they are significant or not and drop off those cooperation variables, one at a time, which are not significant at the level of 10 %, the lagged R & D variables becomes significant in case of product innovation, but not in the case of new products to the market. See table 4b in appendix.

Table 4: The Probit Model: Likelihood of Introducing of New Innovation
(Pooled data for years 1996 and 2000)

Dependent variable (0,1)	**The introducing of product innovation**	**The introducing of process innovation**	**The introducing of the new products to the market**
The name of the explanatory variables	**the coefficient Model 1** (p-values in parenthesis)	**the coefficient Model 2** (p-values in parenthesis)	**the coefficient Model 3** (p-values in parenthesis)
Intercept / Constant	-8.56703*** (0.0016)	3.2897 (0.1782)	-1.5542 (0.5121)
Categories of LUs			
very small LUs (1-9)	3.3724 *** (0.0004)	- 0.5112 (0.5679)	2.1505** (0.0284)
small LUs (10-19)	3.1135 *** (<.0001)	-1.1774* (0.0735)	1.3975** (0.0334)
SMLUs (20-49)	2.0707 *** (0.0012)	- 0.7368 (0.1977)	1.0858* (0.0629)
SMLUs (50-99)	0.9783 * (0.0789)	- 0.7753 (0.1340)	0.9004* (0.0968)
SMLUs (100-249)	0.8853 * (0.0654)	- 0.7074* (0.0814)	0.9852** (0.0364)
Large LUs (250→)	0.0000 *Reference category*	0.0000 *Reference category*	0.0000 *Reference category*
Log Turnover	0.5177*** (0.0008)	0.0437 (0.7445)	0.1390 (0.2809)
Log R & D expenditures (1 year lag)	0.1350 (0.1183)	-0.1759** (0.0229)	-0.0090 (0.9150)
Cooperation			
within enterprise	1.2841*** (0.0010)	0.6888** (0.0216)	0.9775*** (0.0032)
with suppliers	0.8317*** (0.0248)	0.3226 (0.2531)	- 0.2222 (0.4706)
with clients or customers	0.3934 (0.2689)	- 0.0060 (0.9860)	0.3425 (0.3076)
with competitors	- 0.5509 (0.1948)	0.4400 (0.1304)	0.1934 (0.5557)
with consultants	0.3124 (0.4365)	0.0655 (0.8109)	- 0.2682 (0.3957)
with universities and higher education institutes	0.2706 (0.4395)	- 0.3536 (0.2880)	0.3905 (0.2233)
with government or private non-profit research institutes	0.2879 (0.5028)	0.7296*** (0.0125)	0.1629 (0.6148)
n	233	164	161
(Log-likelihood	*-76.3389*	*-85.0519*	*-78.2193)*

LR statistics	χ^2	p - value	χ^2	p - value	χ^2	p - value
Categories of LUs	22.93	0.0003	5.81	0.3251	7.19	0.2069
Turnover	11.78	0.0006	0.11	0.7438	1.18	0.2784
R & D expenditures	2.49	0.1147	5.33	0.0209	0.01	0.9150
Cooperation						
within enterprise	13.11	0.0003	5.35	0.0207	9.26	0.0023
with suppliers	5.27	0.0217	1.30	0.2533	0.53	0.4676
with clients or customers	1.23	0.2665	0.00	0.9860	1.05	0.3066
with competitors	1.71	0.1911	2.31	0.1284	0.35	0.5544
with consultants	0.61	0.4332	0.06	0.8110	0.73	0.3937
with universities and higher education institutes	0.60	0.4396	1.15	0.2826	1.48	0.2239
with government or private non-profit research institutes	0.46	0.4996	6.37	0.0116	0.25	0.6154

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level

exhibit all types of innovations. In a case of product innovations, the cooperation with suppliers of equipments, materials, components or software also seems to be an important factor for new innovations. Results suggest that the co-operation particularly between the different units of the enterprises and the firms of the value-chain, especially cooperation with the advanced suppliers (i.e. backward linkages), are important factors when firms try to introduce new products and services (i.e. product innovations). The result supports the findings of Von Hippel (1978, 1988), i. e. that suppliers can be the origins of new innovations in certain industries.

The results on the process innovations are interesting. We may assume that in many cases the target of the process innovations is to yield productivity gains by reducing production costs, i.e. to make conventional tasks more efficiently with new method of production (Palmberg et al 1999). Our results show that cooperation not only within the enterprise group, but also with competitors and government or private non-profit research institutes can have a positive influence on firm's probability to introduce process innovations.[38]

In a case of new products to the markets, our results implies that if the target of the firms' R & D activity is to innovate significantly improved products to the market, the co-operation within the enterprise group and with universities and higher education institutes improves possibilities to achieve the target.[39]

The role of the labour mobility

As we already have argued, the knowledge is highly embodied in workers of the firm and the output of innovative activity in a firm is the result of their effort to appropriate this knowledge. However, the fact is that this knowledge spills over across the firms, and the inter-firm (both intra- and interregional) mobility of skilled workers probably forms one of the most important channels of technological diffusion. To study the role of the mobility of skilled labour, between the high-tech establishments and academic institutions within and across the regional economies in Finland, to the innovativeness of the Finnish high technology establishments, we collected information about their worker inflows during the period of 1990-2000.[40] The labour mobility inflows to the establishments include following two categories;

a) Inflow of labour from the same sub-region
b) Inflow of labour from other sub-regions

The inflow figures (number of employees) have been proportion to the size of the establishment measured by the number of employees. The size of the establishment in each

[38] If we keep variables of category of size, the turnover and R & D expenditures in models whether they are significant or not and drop off those cooperation variables, one at a time, which are not significant at the level of 10 %, the cooperation with competitors becomes also significant in a case of process innovations. In a case of new products to market, using the same method, the cooperation with universities and higher education institutes becomes significant. See table 4b in appendix. Our findings are some respect opposite to the results of Rouvinen (2002). He found that cooperation with non-academic partners seem to contribute to both product and process innovation, but cooperation with universities and non-profit research organisation had a positive effect only on product innovation, not process innovation. The variables he used to study these effects were, however, slightly different than in our study.

[39] See again table 4b in appendix.

year is measured with the two-year average $EA_i = 1/2^* (E_{it}+E_{i,t-1})$, where E_i is the number of employees in establishment *i* at the end of the year. The aim of this experiment is to analyse whether inflows of labour from different sources form important channels of technological diffusion, (and thereby increase the existing human capital of the establishments) and do they increase or decrease the probability of different type of innovations in the high technology establishments. The proposed hypothesis is the following:

H5: The inflow of labour from other firms and establishments, academic institutions and other sources has a positive effect on establishments' capability to generate new innovations.
"The inflow of labour into the establishments from other firms and establishments, academic institutions and other sources, forms an important mechanism through which knowledge diffuses within and across regions and it has a positive effect on firms' capability to generate new innovations."

In table 5 we have tested the hypothesis (in addition to the hypothesis H1-H4) that the role of labour inflows from the same sub-region and from other sub-regions has a positive effect on the innovation performance. The results concerning the role of size of establishment, turnover, R & D expenditure and cooperation with various external partners (reported in table 4), remain largely unchanged after including the mobility of labour variables. However, results confirm the idea that smaller size in terms of employees contributes both to the product innovation and innovation that are entirely new products to the market. This supports the findings that innovation is most likely to occur in small and medium-sized firms, which have neither the scale nor risk-bearing capacity all of the key inputs on their own (Gordon and McCann 2005).[41] Furthermore, for product innovations in particular, both forward and backward linkages in the value-chain, i.e. cooperation relationships with suppliers and customers seem to have a significant, positive effect on innovations. This is in the line with findings of e.g. Gordon and McCann (2005), Porter (1990) and Von Hippel (1978, 1988). An interesting finding is that cooperation with competitors decreases the probability of innovation. The promotion of standards may motive competitors to form joint ventures in innovation, or at least agree on using common technologies in their products.[42] This may decrease firms' ambitions to innovate and introduce new products that are different than products of their rivals and significantly new.

[40] Based on the information of FLEED-database maintained by the Statistics Finland, we aggregated plant level worker inflows to the local unit level. The sample size is now slightly smaller because not all LUs in a sample provided the data of their worker flows.
[41] We may assume that small and medium sized firms are not only more reliant on external economies of scale, but probably also more capable to form appropriate alliances for R & D projects than their larger counterparts (Gordon and McCann 2005).
[42] Cooperation between Nokia, Motorola, Sony-Ericsson and Siemens (e.g. concerning a next-generation of delivery protocol for cellular phones and devices) is good example of this kind of cooperation.

After controlling establishments' internal characteristics and their cooperation with external partners, worker inflows and thereby the technology diffusion from other firms and institutions has an effect on innovativeness of the Finnish high technology establishments. In cases of product innovations and new product to the market, results suggest that worker inflows from outside the home region increases the probability to introduce new innovations. At the same time, recruiting of labour force from the same sub-region seems to have a negative effect for of innovation. In a case of process innovations, the effects of intra-regional and inter-regional labour mobility on the innovativeness are both insignificant.

Especially during the labour shortage, firms may have to enlarge the area, where they search new labour. In a case when the labour supply of local labour markets does not correspond to firm's labour demand, firm's capability to attract and hire new employees from outside the home region may well help them to get manpower with the required skills. This in turn can provide firm an important new knowledge and know-how and finally, contribute positively to its innovation activity.

These results can reflect the labour market situation in the Finnish high technology industries in the 1990s. Especially in the late 1990s, the Finnish high technology firms, both small and medium sized, had a great shortage of experienced labour force (Simonen and RIS+ Management Unit 2000). This, together with a fact that the mobility of labour was relatively low within the high technology industry, meant that especially small establishments and firms that were not as well known as their larger counterparts might have problems to hire skilled labour outside their home-region, and thereby they were compelled to hire less experienced labour force within their home-region. Transferring experienced worker to train new inexperienced employees binds a lot of resources and which is thus lost from on-going innovation projects and productive work (Power and Lundmark 2004). At the same time those (well known, large) firms, which managed to recruit new, more qualified employees from outside their home-region, had better possibilities to carry out their innovation activities.[43]

In table 5 the population density variable was added to the model to proxy the congestion costs across the region.[44] The results show that after controlling for other factors, innovation activity of establishment is negatively stimulated by a high population density of

[43] In that time the intention of the companies was to agree upon long-term work contracts with their employees. Through 'binding' of employees to companies firms tried to prevent specific expertise from moving to competing companies (Simonen and RIS+ Management Unit, 2000). Furthermore, according to Karlsson and Olsson (1998), large enterprises have an advantage in the sense that they locate their establishments wherever there is manpower with the required skills, while small and medium sized firms with a strong territorial base, have to rely more on the labour that home region can offer. Small firms may also have difficulties in attracting skilled labour (Rothwell and Zegveld, 1982).

[44] This variable reflects, among other things, the role of chances to meet other people (Karlsson and Olsson, 1998).

Table 5: The Probit Model: Likelihood of Introducing of New Innovation (Pooled data for years 1996, and 2000)

Dependent variable (0,1)	**The introducing of product innovation**		**The introducing of process innovation**		**The introducing of the new products to the market**	
The name of the explanatory variables	**the coefficient Model 1**		**the coefficient Model 2**		**the coefficient Model 3**	
Intercept / Constant	-11.2934***	(0.0003)	4.8653*	(0.0613)	-2.7098	(0.2785)
Categories of LUs						
very small LUs (1-9)	4.2112***	(0.0001)	- 0.4490	(0.6378)	2.4499**	(0.0159)
small LUs (10-19)	3.7265***	(<.0001)	- 1.4573**	(0.0373)	1.7020***	(0.0140)
SMLUs (20-49)	2.7921***	(0.0003)	- 0.8467	(0.1738)	1.5578***	(0.0149)
SMLUs (50-99)	1.4674**	(0.0206)	- 1.0568*	(0.0552)	1.0787**	(0.0534)
SMLUs (100-249)	1.0169 *	(0.0640)	- 1.0089**	(0.0232)	1.0076**	(0.0380)
Large LUs (250→)	0.0000	*Reference category*	0.0000	*Reference category*	0.0000	*Reference category*
Log Turnover	0.6576***	(0.0002)	-0.0074	(0.9583)	0.1933	(0.1559)
Log R & D expenditures (1 year lag)	0.2088**	(0.0328)	-0.2010**	(0.0171)	0.0129	(0.8830)
Cooperation						
within enterprise	1.5982***	(0.0007)	0.5991*	(0.0679)	1.0026***	(0.0044)
with suppliers	0.8877**	(0.0368)	0.5354*	(0.0740)	- 0.2250	(0.4970)
with clients or customers	0.7829**	(0.0368)	- 0.0219	(0.9529)	0.3903	(0.2920)
with competitors	- 0.8185*	(0.0882)	0.3330	(0.2988)	0.2804	(0.4167)
with consultants	0.3669	(0.4178)	- 0.0336	(0.9064)	- 0.2955	(0.3637)
with universities and higher education institutes	- 0.1008	(0.8160)	- 0.1832	(0.6317)	0.4328	(0.2476)
with government or private non-profit research institutes	0.6430	(0.2057)	0.8922***	(0.0044)	0.2112	(0.5351)
Mobility of labour from the same sub-region (2 year lag)	- 1.4928***	(0.0067)	- 0.9087	(0.2640)	- 1.3382**	(0.0365)
Mobility of labour from the other sub-regions (2 year lag)	2.0744**	(0.0284)	- 0.5586	(0.6388)	1.4871*	(0.0931)
Population density	- 0.0019**	(0.0446)	0.0003	(0.7659)	0.0002	(0.8472)
n	219		153		151	
(Log-likelihood	*-63.0794*		*-75.5327*		*-70.9855)*	
LR statistics	χ^2	p - value	χ^2	p - value	χ^2	p - value
Categories of LUs	24.05	0.0002	9.88	0.0787	8.49	0.1314
Turnover	14.20	<.0001	0.00	0.9583	2.06	0.1513
R & D expenditures	4.80	0.0284	5.98	0.0144	0.02	0.8830
Cooperation						
within enterprise	14.90	0.0001	3.37	0.0665	8.55	0.0035
with suppliers	4.65	0.0311	3.20	0.0734	0.47	0.4941
with clients or customers	3.64	0.0565	0.00	0.9529	1.12	0.2901
with competitors	3.02	0.0823	1.09	0.2962	0.67	0.4142
with consultants	0.67	0.4126	0.01	0.9064	0.83	0.3609
with universities and higher education institutes	0.05	0.8159	0.23	0.6301	1.34	0.2476
with government or private non-profit research institutes	1.67	0.1961	8.43	0.0037	0.38	0.5363
Mobility of labour from the same sub-region	7.83	0.0051	1.46	0.2262	4.90	0.0269
Mobility of labour from the other sub-regions	5.43	0.0198	0.23	0.6332	3.17	0.0749
Population density	4.18	0.0410	0.09	0.7658	0.04	0.8471

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level the region where it is located.[45] This suggests that higher costs in terms of rents, salaries and land prices in high population density areas seem to decrease the likelihood of product innovations.

5. Conclusions

Our findings suggest that small size of establishment, in terms of employees, seem to contribute not only to the product innovations, but also to innovations that are entirely new to the markets. This supports the argument that small firms can have the innovative advantage in certain industries, like high technology, where firms needs to react quickly and efficiently to changes in market and technological environment. However, as product innovations are positively related to the size of the turnover and R & D expenditure in previous period implies, we cannot conclude that there are not any kind of economies of scale in generation of product innovations.

Process innovations, instead, seem to benefit from the large size of the establishment. Interesting is the result that, after controlling the cooperation behavior with different external partners, an increase in the level of R & D expenditures decreases probability of process innovations. This may imply that establishments increase their R & D expenditures particularly when their target is to introduce new product innovations. Thereby, as their investment on R & D increases, they pay less attention on introducing the process innovations.

The empirical evidence presented in this paper suggests that cooperation with external partners has a positive effect on all three types of innovation. The detail examination of cooperation behaviour reveals that cooperation not only within the enterprise group, but also with advanced suppliers and demanding customers contributes particularly to the product innovations. In other words, it looks that both backward (technology push) and forward linkages (demand push) are important factors for the innovation activity. The cooperation with research centres, in addition to the cooperation within the enterprise group, seems to increase the likelihood of process innovations. Results clearly show that different types of collaboration networks can have a positive effect on the innovativeness of high technology firms. From the aspect of technological policy, results imply that public policy that tries to increase collaboration between various partners, has been a right method to promote innovation activity of the high technology firms in Finland.

The empirical findings concerning the role of labour mobility as a channel of technology diffusion show that worker inflows from other sub-regions have a positive effect on

[45] However, this effect seems to be statistically insignificant in cases of process innovation and new product to the markets.

innovativeness of the high technology establishments. Results implies that hiring workers from outside the home region may well help firms to get manpower with the required skills, provide important new knowledge and know-how for firms and finally, contribute positively to their innovation activity.

The negative effect of labour mobility from the same sub-region in turn suggests that local labour markets (including other firms and institutions), especially when the there is a shortage of skilled labour, may not be capable to provide such kind of labour, and thereby knowledge, i.e. human capital that would contribute positively to the innovativeness. Especially when a firm is not well known outside its home-region, it may be forced to hire less experienced labour force or such kind of labour within their home-region, which do not correspond their labour needs.

The results reported in this paper show that two important channels of technological diffusion, R & D cooperation between the firms and institution and the inter-firm mobility of labour, have an effect on the innovativeness of high technology establishments.

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APPENDIX:

Table 4b: The Probit Model: Likelihood of Introducing of New Innovation (Pooled data for years 1996 and 2000)

Dependent variable (0,1)	**The introducing of product innovation**	**The introducing of process innovation**	**The introducing of the new products to the market**
The name of the explanatory variables	**the coefficient Model 1**	**the coefficient Model 2**	**the coefficient Model 3**
Intercept / Constant	-8.7444*** (0.0010)	3.3955 (0.1589)	-1.4740 (0.5345)
Categories of LUs			
very small LUs (1-9)	3.3435*** (0.0002)	-0.4724 (0.5893)	2.0968** (0.0285)
small LUs (10-19)	3.1018 ***(<.0001)	-1.1586* (0.0742)	1.3083** (0.0417)
SMLUs (20-49)	2.0766*** (0.0006)	-0.7138 (0.2042)	0.9902* (0.0797)
SMLUs (50-99)	0.9990** (0.0565)	-0.7924 (0.1264)	0.8576 * (0.1071)
SMLUs (100-249)	0.8773** (0.0573)	-0.7676** (0.0550)	0.9036** (0.0432)
Large LUs (250→)	0.0000 *Reference category*	0.0000 *Reference category*	0.0000 *Reference category*
Log Turnover	0.4903*** (0.0006)	0.0611 (0.6377)	0.1324 (0.2917)
R & D expenditures (lag)	0.1706** (0.0280)	- 0.2070***(0.0050)	- 0.0058 (0.9420)
Cooperation			
within enterprise	1.4745*** (<.0001)	0.6975***(0.0082)	0.9974*** (0.0009)
with suppliers	1.1559*** (<.0001)		
with clients or customers			
with competitors		0.5035** (0.0561)	
with consultants			
with universities and higher education institutes			0.4842* (0.0794)
with government or private non-profit research institutes		0.6888***(0.0066)	
n	233	164	161
(Log-likelihood	*-79.4198*	*-86.1886*	*-79.4742)*

LR statistics	χ^2	p - value	χ^2	p - value	χ^2	p - value
Categories of LUs	25.12	0.0001	6.43	0.2663	6.90	0.2282
Turnover	12.26	0.0005	0.22	0.6361	1.12	0.2893
R & D expenditures	5.01	0.0253	8.24	0.00413	0.01	0.9420
Cooperation						
within enterprise	21.26	<.0001	7.05	0.0079	11.81	0.0006
with suppliers	19.50	<.0001				
with clients or customers						
with competitors			3.67	0.0553		
with consultants						
with universities and higher education institutes					3.06	0.0801
with government or private non-profit research institutes			7.45	0.0064		

*** significant at the 1% level, ** significant at the 5% level, * significant at the 10% level