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A Portrait of the Innovative Firm as a Small Patenting Entrepreneur

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Abstract

This paper examines small innovative entrepreneurs by contrasting patenting firms against non-patenting firms. The empirical analysis is based on new and unique data on internal attributes, location and international trade characteristics for over 20 000 manufacturing firms in Sweden with 1-25 employees. Our main findings are that firms' access to financial means, human capital and trade with R&D-intensive economies correlate highly significant with their propensity to be engaged in innovation activities, as evidenced by patent applications. Interestingly, when controlling for firm attributes we do not find any significant effect of the local milieu on innovativeness among micro and very small firms.

Keywords: Entrepreneurship, Innovation and Invention, Intellectual Property Rights, New Firms, Technology Transfer, Location

JEL: F43, L26, M13, O31, O34

1. INTRODUCTION

Small firms are considered to be a key for entrepreneurial spirit and innovation. They are frequently maintained to introduce new technology and variety into the economic system, thereby stimulating economic growth. In accordance with the Schumpeterian 'Mark I hypothesis' (Schumpeter 1934), considerable research over the recent decades suggests that small firms account for a significant share of innovations and employment growth. See Birch (1979), Rothwell (1989), Acs and Audretsch (1988 and 1991), Scherer (1991), Davidsson et al. (1994) and Audretsch (2002).

Acs and Audretsch (1987) show that small firms play a particularly important role in highly innovative industries with significant technology opportunities. These firms are also a source of expanding technological capabilities by large and established firms. Using Swedish data, Utterback and Reitberger (1982), and Granstand and Sjölander (1990) find that large firms often purchase small firms in order to acquire their technology and innovations.

Despite a vast literature on the importance of small innovators, we still lack detailed and knowledge on the very small innovative entrepreneurs. Most of the present studies are based either on case studies with or quantitative studies using poor or modest information. The increasingly popular datasets based on the EU-wide Community Innovation Survey (CIS) contain patenting information, but mostly only for firms with 10 or more employees. Moreover, they do not provide detailed information on the characteristics of non-innovative firms. One consequence of this is lack of guidelines for policy initiatives aimed at stimulating innovation activity in micro firms and foster their growth potential.

The objective of this paper is to increase the knowledge of very small innovative firms. In order to do this we contrast small patenting firms against non-patenting firms using data on firm attributes, the local milieu and participation in international trade for more than 20 000 small and micro manufacturing firms in Sweden observed over the five year period 2000-2004. Our key variable for classifying a firm as innovative is patent applications for the domestic market. Although the use of patents as indicators of innovation has been debated, many scholars argue that it is a fairly reliable measure (see Griliches et al. (1987) and Acs et al. (2002) for a discussion).[1]

In 1980 Ariel Pakes and Zvi Griliches published their seminal paper "Patent and R&D at the Firm Level: A First Look". Their paper reported on the relationship between patent applications and R&D expenditures based on data for 121 large U.S. companies covering an 8-year period. The study had two main conclusions. First, there is a statistically significant relationship between a firm's R&D expenses and the number of patent it applies for and receives. They described the link between R&D and patent as a

[1] Acs et al. (2002) compare innovation counts (often argued to be one the best measures of innovation) and patents across US regions and conclude; "the empirical evidence suggest that patents provide a fairly reliable measure of innovative activity" (p.1080).

"knowledge production function". Second, this relationship is very strong in the cross-section dimension but considerable weaker in the within-firm time series dimension. Using refined econometric methodology and richer micro data sets, over past decades many applied studies have confirmed the basic findings by Pakes and Griliches (1980).

The current paper will take a step back from the knowledge-production-function literature and ask the fundamental questions: which are the main determinants to a firms´ decision to be engaged in innovation activities? We will limit the analysis to two categories of firms that typically report no formal R&D and which can be classified as occasional innovators. In average, an innovative firm in our sample applies for patent only once over a five year period.

Our intention here is to picture the landscape of small innovative entrepreneurs and we focus on descriptive statistics and simple propensity estimations. In order to construct a dataset that fulfils our requirement for a detailed portrait of a small entrepreneurial firm, several data sets have been merged. The initial data consist of 106,756 balance-sheet observations on all about 20 000 manufacturing firms in Sweden with 1-25 employees observed over the period 2000-2004. For the same period, we have then added information on patent applications, human capital, internationalization activities as well as characteristics of the regional milieu including proximity to university and corporate R&D as well as knowledge workers. The final dataset separated between micro firms (1-10 employees) and very small firms (11-25 employees).[2] This allows us to conduct an empirical analysis of innovation in micro firms, as evidenced by the probability to apply for a patent, with information that to the best of our knowledge has not been analyzed in previous literature.

Our main findings are that firm attributes and characteristics of their international trade activities are the main determinants for the propensity of small and micro firms to be innovative. When controlling for firm attributes we do not find any significant effect of the local milieu.

The remainder of the paper is outlined in the following fashion. Section 2 presents the theoretical framework, which focus on how economic firm and sector characteristics, location attributes and international trade activities are related to innovation. The theoretical discussion provides the basis for formulation of a set of hypotheses regarding the influence of each set of variables on innovation in micro firms. Section 3 describes the data and presents descriptive statistics. Section 4 conducts an econometric analysis of the relationship between the three sets of variables and the probability to patent. Section 5 concludes.

[2] To see the truly smallness of this type of firms, consider that Acs and Audretsch (1987 and 1988) as well as Acs et al. (1994) define "small firm innovations" as innovations by firms with less than 500 employees. In 2003 the EU commission adopted a definition stating that micro firms are those with 10 or fewer employees whereas small firms are those with between 11 and 50 employees.

2. THEORETICAL FRAMEWORK

What factors are pertinent for portraying and explaining innovation in firms? Guidelines are provided by several different literatures. We focus here on three sets of factors: (i) economic characteristics of the firm, (ii) location attributes and (iii) international trade and associated linkages to foreign markets (see Figure 1). Economic characteristics of the firm are supposed to capture its ability to generate new ideas as well as its capacity to transform them into new products or processes. Location characteristics reflect the potential for knowledge and information flows to the firm from the regional environment. International trade characteristics describe the firm's links to foreign markets and the potential for knowledge and technology transmission to the firm from abroad.

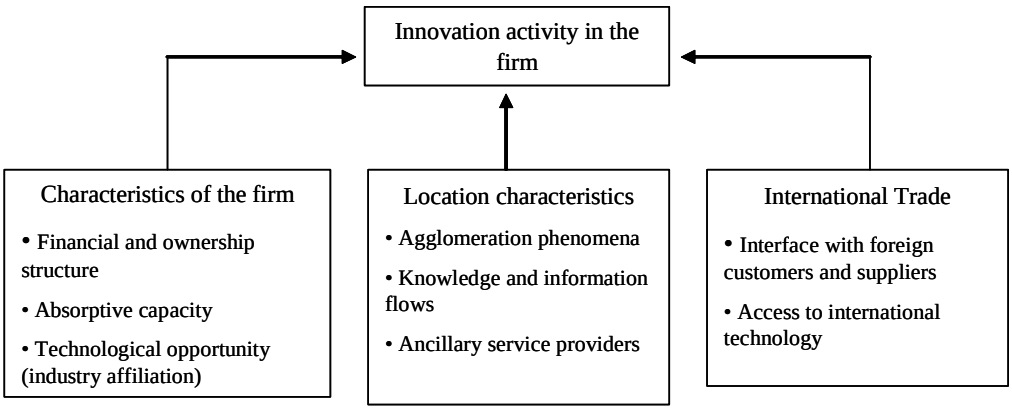

Figure 1. Three types of factors that can portray and explain innovation activities in firms.

2.1 Characteristics of firms and their sectors

The key assertion in the resource based view of the firm (RBV), which build on the contribution by Penrose (1959), is that a firm's competitive advantage depends on internal heterogeneous resources and capabilities (Barney 1991). According to this view then, differences in innovation among firms are to be found in disparities in their internal characteristics. The Schumpeterian literature builds on similar premises, although the role of sector characteristics is typically made more explicit.

Consistent with the RBV and Schumpeterian literature, several studies find that characteristics of the firm and the sector they operate in indeed can explain innovation (see e.g. Kleinknecht and Mohnen 2002, Cohen 1995, Cohen and Klepper 1996, Crépon et al. 1998, Klette and Kortum 2004, Pavitt 1984). We will here review a set of characteristics that the literature suggests is important for firms' innovation activity. They are human and physical capital, financial and ownership structure, size and sector affiliation.

In addition to R&D, physical capital and human capital (other than the R&D personnel) are commonly employed as key determinant in the Schumpeterian innovation and productivity literature. A vast empirical literature has convincingly shown that physical capital is a major driving force to economic growth at various levels of aggregation. One explanation is that new knowledge is embedded in capital investments (see Hulten (2001) for a discusion). A firm's human capital is maintained to reflect capacity to absorb, assimilate and develop new knowledge and technology (Bartel and Lichtenberg 1987, Cohen and Levinthal 1990). Several empirical studies also find that technological change tends to be skill-biased and change the relative labor demand in favor of highly skilled and educated workers (see e.g. Berman et al. 1998, Machin and van Reenen 1998). In view of this we expect that a firm's physical and human capital is positively related to innovation.

As innovation is often associated with risks and costly investments in knowledge and technology, the financial structure of a firm is another relevant characteristic. Because problems with asymmetric information between potential financiers (venture capitalists, banks and other financial institutions) and the firm are more pronounced with regard to investments in innovation, internal cash flow is an important source of finance for innovation activities (Hall 2002).This is especially the case for small and young firms with limited access to capital markets and associated difficulties in finding external sources of funds for their innovation investments (Himmelfarb and Petersen 1994).[3] We hence expect that access to capital is positively associated with innovation activity. In the empirical analysis we use profit and equity as indicators of access to internal finance, while we measure external financial means in terms of long term debt and short term debt.

Recent literature shows that corporate ownership structure is associated with innovation. There are two basic reasons for this. First, in contrast to non-affiliated firms (NAFs) and uninational firms (UNIs), multinational firms (MNEs) have by definition established networks to a rich set of markets and thereby a coupling to several knowledge sources and a presence in innovation systems associated with different markets (cf. Dachs et al. 2008). MNEs also have strong internal capabilities pertaining to the development of proprietary information and knowledge within the corporation (Pfaffermayr and Bellak 2002).[4] Small firms that are part of a multinational corporation (either domestic or foreign owned) can thus be expected to be more innovative because of access the MNEs knowledge and information networks and technology.

[3] Scherer (1999) maintains that R&D outlays in large established firms are often of such magnitude that "…they can be financed through routine cash flow and, if need be, can resort to outside capital sources willing to provide funds on full faith and credit without detailed inquiry into the specific uses to which the funds will be put" (ibid. p.72). He argues further that this is one reason why empirical studies of internal cash flow and R&D among larger firms do not find systematic relationships.

[4]MNEs have for instance high ratios of R&D relative to sales, a large number of scientific, technical and other 'white-collar' workers as a percentage of their workforce, high value of intangible assets and large product differentiation efforts, such as high advertising to sales ratios (van Marrewijk 2002).

Second, it is well known that mergers and acquisitions is an important means by which MNEs expand. As discussed in the introduction, one reason why a MNE may acquire a micro firm is that the latter has developed new knowledge and technology pertinent for an MNE.

Firms are active in different sectors, and different sectors have different technology and innovation opportunities (Dasgupta and Stiglitz 1980ab). Certain industries can over a sequence of periods be characterized by rapid technological progress, translating into high technology and innovation opportunities. This is typically the case in the early phases of a technology's life cycles (cf. Vernon 1966). Small firms tend to have an innovation advantage precisely in high-technology and skill-intensive sectors in which technology and innovation opportunities are high (Acs and Audretsch 1987). The literature thus suggests that characteristics of a particular sector or industry can influence innovation. In the empirical analysis we therefore include indicators of the technology level in sector the (micro) firms belong to as a determinant of innovation and we expect that the innovation in micro firms is highest in high-technology sectors.

2.2 Location characteristics

Durable characteristics of a firm's location describe its production milieu (Johansson and Wigren 1996). Such a milieu comprises material infrastructure in the form of roads and buildings, as well as immaterial infrastructure in the form of knowledge and competencies of the regional workforce, ancillary services, universities and other R&D institutions. Several authors have made the argument that properties of the production milieu in a location can have an impact on the performance of the firms it hosts. Marshall (1920) maintained that concentrations of firms in a similar industry give rise to localization economies in the form of knowledge and information spillovers, labor pooling (advantages of thick markets for specialized skills) and backward and forward linkages. Ohlin (1933) and Hoover (1937) distinguished between urbanization and localization economies, where the former refers to economies that pertain to larger urban regions with a diversified economy.[5] Both concepts build on the notion of place-specific external scale economies (cf. Fujita and Thisse 2002).

A main argument in the literature is that the potential for and intensity of knowledge and information flows are a particularly relevant location characteristic in the context of innovation (Feldman 1999, Glaeser 1994). This type of flows provides firms with knowledge and information of novel products, designs, technologies and technical solutions, and can constitute the basis for a firm's innovation ideas (Andersson and Johansson 2008). Several studies using proxies for the potential of spatial

[4] The notion of urbanization economies correspond closely to the ideas in Jacobs (1969) who emphasizes the role of diversity in regional economies.

knowledge and information flows find results that are consistent with such a hypothesis. Innovation activities are for example more concentrated in space than standard production activities (Audretsch and Feldman 1996), patent citations are geographically localized (Jaffe et al. 1993) and innovations tend to diffuse faster within clusters (Baptista 2000).

Geographic proximity and density are frequently shown to be positively related to innovation and productivity (Ciccone and Hall 1996, Rauch 1993). Dense urban regions with richness in sectors and knowledge sources offer interaction opportunities with different actors embodying relevant knowledge, such as customers, knowledge intensive business services, universities and other 'knowledge-handlers'. Moreover, flows of labor and technical personnel between firms tend to be greater in dense locations, which stimulate the diffusion of competencies and knowledge embodied in people (Almeida and Kogut 1999, Moen 2005, Fallick et al. 2006). A similar argument applies regarding proximity to universities and their students, graduates and R&D staff (Varga 1997).

An interesting finding in the literature, for the purpose of the present paper, is that the regional milieu is particularly important for small firms. In a seminal study, Acs et al. (1994) investigated from where small firms get their innovation inputs from, since they produce innovation output with limited R&D resources compared to large firms. The authors tested the hypothesis that small firms capitalize on flows of knowledge and information from corporate R&D in large firms and universities, and that such flows are stimulated by their geographical proximity. They applied the model developed in Jaffe (1989), in such a way that innovation in activity in US states where regressed on industry R&D, university R&D and an index of their geographical coincidence. By partitioning each state's total innovations into those developed by small and large firms, they showed that the geographical coincidence index was only significant for small firm innovations. Although they did not control for characteristics of the firms, as suggested by the RBV and Schumpeterian literature, the findings in their study constitute significant evidence of the role of knowledge and information flows for innovations in small firms.

Ample later studies find that characteristics of locations pertaining to the potential and frequency of such flows are important, not only for innovations in small firms but also start-up activity. It is by now established in the literature that "…entrepreneurial activity will tend to be greater in contexts where investments in new knowledge are relatively high, since the new firm will be started from knowledge that has spilled over from the source actually producing that knowledge" (Acs et al. 2006, p.12). In view of this, we expect that location characteristics pertaining to the potential for knowledge and information flows are important for innovation in micro firms. In the empirical analysis we use accessibility to human capital, regional size and within- and across-industry co-location phenomena as basic indicators of this potential.

2.3 International trade

Several studies of international trade through the lens of the individual firm find that, conditional on an extensive set of firm characteristics, firms that participate in international trade are more productive (see Greenaway and Kneller 2007 or Wagner 2007 for surveys). Recent evidence from Sweden is provided by Andersson et al. (2008). The literature offers two not mutually exclusive hypotheses capable of explaining such a pattern. The first is that firms engaged in international trade have *ex ante* productivity advantages, presumably based on some form of innovation (Andersson and Ejermo 2008), enabling them to overcome sunk costs associated with foreign sales. The second is that firms that trade internationally have better access to foreign knowledge and technology, which stimulate innovation and productivity. With regard to export activity this effect is referred to as 'learning-by-exporting', though empirical analyses do not find systematic evidence for this effect.

There is a related literature focusing on international technology diffusion, which regards imports as an important vehicle for such diffusion (Keller 2004). The conceptual framework for this literature is derived from R&D-based models of growth and trade in which technology and knowledge is embodied in differentiated intermediate capital goods (cf. Rivera-Batiz and Romer 1991, Eaton and Kortum 1999 and 2002). New intermediate goods are outcomes from investments in R&D. Domestic firms can then access foreign R&D by importing the intermediate goods produced in the foreign country.[6] From this perspective imports from R&D intensive countries, such as G7 countries accounting for over 80 % of the total R&D investments in the world, is a source of a firm's knowledge and technology. In summary, firms with export and import activities are more likely to have strong competitive advantages based on innovation, and they are also expected to be more exposed to foreign knowledge and technology which further stimulate innovation activity.

3. DATA

The data base used is this study covers the period 2000-2004. In order to construct a dataset that fulfils our requirement for a detailed portrait of a small entrepreneurial firm, several data sets have been merged. The initial data consist of 106,756 observations on all manufacturing firms in Sweden with 1-25 employees. There data contain information on firm characteristics such as sales, value added, profit, physical investment, equity, debt, corporate ownership structure and human capital. In a second stage the data have been added with information on the local milieu that includes location and access to human capital. In a third stage, we have added trade statistics for all individual firms. Finally, the data set has been merged

[5] The analyses in Keller (2002), Acharya and Keller (2007) and Lööf (2007) provide recent evidence that imports of intermediate capital goods from foreign countries are a source of domestic firms' productivity.

with a dataset from the Swedish Patent Office (PRV). It contains information on all Swedish firms with an organisational number (firm identity) that applied for one or more patent over the period 2000-2004. More than 80 % of all applicants have a firm identity.

Innovators that try to protect an idea decide which market their protection will cover. PRV awards intellectual property protection for the Swedish market. Over the period 2000-2004 Swedish firms with domestic or foreign owners applied for about for more than 13 000 patent domestically. Roughly 50 % of the applications were granted.

Our intention is to examine the influence of three categories of sources that affects firm propensity to be innovative: (i) idiosyncratic, (ii) the local milieu and (iii) global sources. A second objective is to explore whether the determinants to be innovative is the same or similar for small firms, which we in this paper defines as 11-25 employees, as for micro firms. We therefore split the dataset into 90,120 observations on micro-firms and 16,636 firms on small firms. Among the first group we have 296 observations on patent applications and 196 in the latter.

4. EMPIRICAL ANALYSIS

Studying the correlation between patent and its determinants raises the question of causality and a dynamic panel data methodology is preferable. Since majority of the observed applicant only applied for one patent during the observed period the econometric ambitions of the paper has been limited to investigate the propensity to apply for patent and this section presets the regression results from a logit estimator.

4.1 Economic characteristics of firms

We first proceed with a comparison of the descriptive statistics of firms attributes for all firms and patenting firms. In the discussion we distinguish between micro firms (1-5 employees) and small firms (11-25 employees). The left part of Table 1 reports mean and standard deviations for 90,120 observations on all micro firms in the Swedish manufacturing industry and 296 observations on only patenting micro firms. The latter group constitutes 0.4 % of all micro firms. The corresponding figures for small firms are 16,636 observations on all firms over the five year period and 99 observations on patenting firms. The fraction of patent applicants is 1.4 %.

The main message of table 1 is the following: Patenting firms are distinguished from non-patenting firms and the difference is more pronounced among micro firms than among other small firms. Controlling for firm size, patenting micro firms have 60 % higher sales, 60 % higher profit, 30 % higher wages, 210 % more equity, 130 % more short term debt and 150 more long term debt than the

mean value for all micro firms. Moreover, patenting micro firms are considerable more human capital intense and physical capital intense than non-patenting micro firms. Regarding small firms 11-25 employees, patenting firms have 10-20 % higher sales, profit and value added than other firms and 40-80 % more internal and external financial means. Similarly to micro firms, we also see that patenting firms are more intense in human and physical capital than other firms. The bottom part of Table 1 reports that 3% of the micro forms belongs to a MNE-group and that this fraction is five times higher (15 %) among patenting MNEs. Looking at the 11-25 group, we see that 15% of all firms are part of a MNE group compare to one out of three innovators. However, the typical the applicant and small manufacturing firms in Sweden is a non-affiliate firms that are classified as a high medium or low medium technology firm.

Table 2 presents the results of estimating the propensity to apply for patent using the data on firm characteristics reported in Table 1. Staring with micro firms, we find that sales and physical capital (proxied by intermediates) are neutral with respect the likelihood to be and patent applicant when micro firms are considered. Though, the coefficient estimate for the latter variable is positive and significant at the 5 % level of for small firms.

Turning then at our four finance variables, Table 2 report some interesting similarities and differences between micro firms and small firms. The literature has convincingly shown that given the existence of asymmetric information between firms and lenders, investment in innovation activities must be primarily funded by internal resources of firms. Our study suggests that this finding is not obviously applicable on the smallest and the very smallest firms. First, it is shown that innovation performance expressed as patent application among entrepreneurs are not sensitive to the firm's current profitability with proper controls for idiosyncratic differences and sector classifications. Second, row four reports that patent application is a highly significant and increasing function of equity per employee among small firms. The corresponding coefficient is positive also for micro firms, but not at the highest significance level. Long term debt correlates significant with patenting for both categories of firms while short term is significant only for micro firms. Summarizing the effect of internal and external finance, we conclude that the "liquidity" effect is quite visible. We also provide some evidence that access to external financial sources are relatively more important for micro firms compared to small but not very small firms.

Commonly the innovation literature includes both firm size and human capital among the covariates. Though, in order to avoid double counting, we adopt the suggestion by Hall (2007) and separate university educates employees from other workers. We find that the former is highly associated with the propensity to patent for both categories of firms while the latter is negatively associated with our innovation measure.

The bottom part of Table 2 displays the importance of corporate ownership structure and sector classification. Among the smallest entrepreneurs, there is some evidence (at the 5 % level) that association with a multinational company correlates positively with the dependent variable, whereas the ownership

structure variables are non-significant in the larger firms. Finally, the table reports the low technology firms have a less likelihood than other firms of being a patent applicant.

4.2 Local environment

Table 3 shows statistics about the relevance of the local environment. Among several possible measures, we select two indicators supposed to capture factors suggested in recent literature. The first expresses accessibility to human capital. This variable measures the total accessibility to employees with a long university education ($\geq$ 3 years) of the local labor market (LLM) region the firm is located in. A LLM region consists of municipalities that together form an integrated labor market. LLM region *r*'s accessibility to human capital is calculated as a weighted average of the human-capital accessibility of the municipalities that belong to the region: $\sum_{k\in r}\theta_k \sum_{k\in K} \exp\{-\lambda t_{ks}\}H_s$, where H_s denote the number of employees in municipality *s* with a long university education, t_{ks} is the time distance between municipality *k* and *s*, and λ is a distance-friction parameter. θ_k denotes the weight of municipality *k* in region *r*, measured as *k*'s share of the total population in region *r*. The set *K* contains all municipalities in the economy and *r* represents all municipalities that belong to region *r*. Our second indicator informs whether or not the firm is located in some of Sweden's three major city regions: Stockholm, Göteborg and Malmö. These regions are distinguished from other regions by being the only major metropolitan areas in Sweden, with diversity in sectors and richness in knowledge sources.

Considering first the left part of the table, Row 1 shows no difference in accessibility to human capital between patenting micro firms and other manufacturing firms with 1-5 employees. Partly this reflects the statistics presented in Rows 2-6 of the left part of Table 3: The fraction of firms located in the two larges Swedish cities Stockholm (21 %) and Göteborg (10 %) is the same for the two categories of entrepreneurs. Although the third Swedish metropolitan area (Malmö), has relatively less innovative entrepreneurs than other Swedish regions, the descriptive statistics don't indicate that entrepreneurial firms in rest of Sweden are less innovative than other entrepreneurs. The right part of Table 3 (11-25 employees) reports an over-representation of applicants in Stockholm, whereas the number of applicants is less than proportional among firms in the two other Swedish metropolitan regions.

In Table 4-6, we keep three categories of covariates from the first logit-equation reported in Table 2: log intermediates per employee, log university and log non-university employment, and sector classification. In contrast to what could be expected from the literature discussed in Section 2, the regression results presented in Table 4 suggest that the local milieu has no impact on the propensity to apply for patent among small and very small entrepreneurs in the manufacturing sector. One possible explanation of this puzzling finding can be that we only consider whether or not a firm apply for a patent.

When looking at the total number of patents applied for by small and micro firms, thus recognizing that an individual firm can apply for several patents, we see that the metropolitan regions have a disproportionate large fraction of the total number of domestic patent applications.

4.3 International trade and linkages to foreign markets

Table 5 reports the summary descriptive statistics for trade statistics and in Tables 6 and 7, we assess the relevance of international trade by looking at the correlation between export and patent application.
Several things stand out. First, we see that innovative firms are considerable more engaged in export activities. The typical micro firms in Swedish manufacturing exports 3.1 % of its sales. The corresponding figure for patenting firms with 1-5 employees is more than four times higher (13.0 %). An average manufacturing firm in Sweden in the size-class 11-25 employees exports one tenth of its production. Among patenting firm this figure is one third. Further, the top part of Table 5 reveals that patenting firms have 3-4 times more export products and export destinations, compared to non-patenting firms. The most striking finding reported in the table concerns exports to the seven most R&D-intensive countries in the world (the U.S, the U.K, Germany, France, Italy, Japan and Canada). Whereas 3 % of the micro firms have export partners within the G7, the mid part of Table 5 reports that 19 % of patenting exports to G7. Looking at the small firms, the table informs that 11 % succeed to compete on the world's most knowledge-intensive market compared to 28 % of the firms that apply domestically for intellectual property protection of their inventions.

Our unique database also allows examining differences in import-behaviour between patenting and non-patenting entrepreneurs and between small firms and micro-firms. The most interesting finding refers to import from the G7. It can be assumed that this import is associates with a higher degree of technology transfer than imports from other markets. While 5 % of micro firms in general are benefiting from knowledge embedded in G7-imports, the statistics shows that this figure is 20 % among micro firms. Considering small firms 15 % are importing from G7 compare to 31 % of small patenting firms.

Tables 6 and 7 report the propensity to apply for patents, when import trade characteristics are included as determinants. Other control variables are physical capital, human capital, size and sector-dummies. The upper part of Table 6 reports that patent application has a highly significant correlation with number of export destinations and export fraction to the G7 countries. Turning to the relationship between patent and import, an issue largely over-looked in the literature, Table 7 has two interesting findings to report. First, we see that the estimated elasticities for number of import origins are highly significant for micro firms and small firms as well. Second and quite surprisingly, Row 2, suggest that the fraction of import correlates highly significant with the probability to apply for patent only among micro-firms. The

coefficient estimate is significant only at the weakest acceptable level of significance (10 %) among small firms.

Table A and B in Appendix report regression results for model specifications including both the full set of firm attributes reported in Table 2 and the trade variables reported in Tables 6-7. Including a broader set of control variables does not change the main results of the paper.

4.4 Summary findings

This section has examined determinants to be innovative among small and very small firms. In the descriptive statistics we compared firms that apply for patent applications with all manufacturing firms in Sweden in two different size-classes, 1-10 and 11-25 employees. Table 1 showed that patenting firms were distinguished from other firms. In particular, they had higher human capital, were more profitable, paid higher wages, and had better access to internal and external sources of finance. The logit regression results in Table 2 showed that the main firm characteristics that determines the probability to apply for a patent were long- and short-term debt and equity expressed in intensity terms (per employee). The regression also showed that the propensity of being innovative was an increasing function of human capital. Tables 3 and 4 reported the importance of location characteristics. The variables investigated were accessibility to human capital and the importance of large metro-regions with a diversified and dense local economy. Somewhat surprisingly, we did not find that any of these location characteristics matter for micro firms (1-10 employees) or small firms (11-25 employees). These results were the same irrespective of whether we controlled for firm attributes or not. The major finding from Tables 5 and 6 was that micro firms engaged in international trade were considerably more likely to be innovative. In particular we found that trade relations with G7 countries, the most R&D intensive club of countries of the world, were highly associated with the probability of being innovative.

5. CONCLUDING REMARKS AND FURTHER RESEARCH

This paper has portrayed innovative firms as small patenting entrepreneurs using a new and unique data set and a simple methodological framework. In the analysis, 395 observations on micro-firms (1-5 employees) and small firms (6-25 employees) have been compared with all existing manufacturing firms in Sweden over a the period 2000-2004. In total, our dataset includes over 100 000 observations on these two groups of entrepreneurial firms. The main contributions of the study are as follows:

1. We have shown that innovative small and micro firms that apply for patents are distinguished from non-patenting firms: they have more human capital, they are more profitable and have more equity capital, pay higher wages, have better external sources of finance.

2. Innovative firms are also participating considerable more in international trade than other firms. In particular, they trade more goods, have more trade partners and are more intensively engaged in trade with the most R&D intensive countries in the world (G7).

3. Patenting entrepreneurial micro firms are not over-represented in metropolitan areas. Moreover, when controlling for firm attributes we do not find any significant effect of the knowledge accessibility on innovativeness, as evidenced by the likelihood of applying for a patent.

4. The substantial empirical findings from the econometric analysis are that firms' finance, human capital and trade with R&D-intensive economies correlate highly significant with their propensity to be engaged in innovation activities requiring intellectual property protection.

The results presented in this paper are limited to manufacturing firms. The basic data in the analysis could be examined also for service firms. Comparing entrepreneurs in both manufacturing and services and identifying sources that influence their capacity to make substantial inventions is an important topic for future research. Another research issue is to examine a category of firms that has been overlooked in systematic analyses, i.e. individual entrepreneurs (firms with 0 employees). These are often excluded from systematic analyses, because of lack of information about their economic characteristics. This is unsatisfactory as they account for a substantial fraction of domestic patents.

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TABLE SECTION

Table 1, Summary descriptive statistics. Firm characteristics, in 1000 Euro

	1-10 Employees				11-25 Employees			
	All firms Obs 90,120		Patent applicants Obs 296		All firms Obs 16,636		Patent applicants Obs 199	
	Mean	*StD*	Mean	*StD*	Mean	*StD*	Mean	*StD*
Patent application	0.4 %	*0.83*	100 %		1.2 %	*10.7*	100 %	
Emp	3.4	*2.5*	4.1	*2.7*	16,2	*4,1*	17.2	*4.0*
Human capital	12.6 %	*25.6*	37.7 %	*38.3*	13.2 %	*15.5*	25.7%	*21.0*
Sales	443	*1,022*	864	*1,273*	2,330	*2,485*	2,861	*1,701*
Intermediates	289	*919*	596	*924*	481	*1,260*	1,115	*1,274*
Value added	154	*202*	267	*371*	810	*804*	973	*504*
Profit	73	*144*	142	*322*	379	*757*	446	*418*
Wage cost	81	*84*	125	*141*	431	*163*	527	*210*
Equity	98	*488*	362	*1,095*	482	*1,924*	943	*2,002*
Short term debt	99	*285*	273	*679*	560	*2,234*	833	*1,667*
Long term debt	74	*243*	224	*710*	418	*2,402*	737	*2,059*
Machin-build invest	42	*111*	78	*187*	291	*2,392*	345	*1,128*
Non-Affiliate	83.4 %	*37.1*	64.8 %	*47.8*	50.2 %	*50.0*	39.1	*48.9*
Uninational	13.3 %	*34. 0*	19.9 %	*40.0*	34.9 %	*47.6*	30.1 %	*46.0*
Swedish MNE	1.8 %	*13.3*	9.4 %	*29.3*	9.1 %	*28.8*	20.6 %	*40.5*
Foreign MNE	1.4 %	*11.6*	5.7 %	*23.3*	5.6 %	*23.1*	10.0 %	*30.1*
High Technology	6.8 %	*25.1*	20.9 %	*40.7*	5.3 %	*22.5*	15.5 %	*36.3*
High med. technology	16.5 %	*37.1*	31.7 %	*46. 6*	21.0 %	*40.7*	38.1 %	*48.7*
Low med. technology	32. 4 %	*46.8*	30.7 %	*46.6*	35.1 %	*47.7*	31.6 %	*46.6*
Low technology	43.2 %	*49.5*	16.5 %	*37.2*	38.4 %	*48.6*	14.5 %	*35.3*

Table 2: Logit regressions. Determinants to apply for patents. Firm Characteristics

	1-10 emp	**11-25 emp**
Sales	-0.091	0.130
	(0.87)	(0.69)
Profit	-0.041	-0.066
	(1.49)	(1.71)
Intermediates	0.038	0.129
	(1.17)	(2.44)*
Equity	0.085	0.168
	(2.47)*	(2.83)**
Long term debt	0.088	0.072
	(4.58)**	(2.82)**
Short term debt	0.383	0.086
	(4.57)**	(0.66)
Non university labour	-0.099	0.042
	(3.40)**	(0.29)
University labour	0.227	0.252
	(8.53)**	(4.85)**
Domestic MNE [a]	0.540	0.294
	(2.24)*	(1.34)
Foreign MNE [a]	0.633	0.146
	(2.29)*	(0.54)
Domestic UNI [a]	0.223	-0.055
	(1.42)	(0.31)
High technology [b]	1.855	1.823
	(9.48)**	(6.63)**
High medium technology [b]	1.440	1.490
	(8.08)**	(6.62)**
Low medium technology [b]	1.002	0.979
	(5.59)**	(4.27)**
Constant	-7.242	-7.132
	(18.57)**	(9.21)**
Observations	90120	16636

Notes: The variables are in per employee terms and in logarithms. Absolute value of z statistics in parentheses. * significant at 5%; ** significant at 1%. (a) Reference alternative is domestic non-affiliates. (b) Reference alternative is Low technology sector

Table 3, Summary descriptive statistics. Location characteristics

	1-10 Employees				11-25 Employees			
	All firms Obs 90,120		Patent applicants Obs 296		All firms Obs 16,636		Patent applicants Obs 199	
	Mean	*StD*	Mean	*StD*	Mean	*StD*	Mean	*StD*
Human capital access.	8,613	*112,65*	8,606	*113,68*	6,695	*100,55*	7,636	10,992
Metro 1: Stock	20.6 %	*40.4*	20.9 %	*40.7*	14.6 %	*35.3*	18.5 %	*39.9*
Metro 2: Gbg	9.8 %	*29.8*	9.7 %	*29.7*	8.7 %	*28.3*	7.0 %	*25.6*
Metro 3: Mal	6.2 %	*24.1*	4.3 %	*24.1*	5.7 %	*23.2*	4.5 %	*20.8*
Rest of Sweden	63.2 %	*48.2*	64,8 %	*47,8*	70.8 %	*45.4*	69.8 %	*46.0*

Table 4: Logit regressions. Determinants to apply for patents. Location Characteristics

	1-10 emp	**11-25 emp**
Human capital access.	-0.034	-0.009
	(0.56)	(0.11)
Metro 1: Sthlm [a]	-0.012	0.182
	(0.05)	(0.55)
Metro 2: Gbg [a]	-0.175	-0.406
	(0.69)	(1.16)
Metro 3: Mal [a]	-0.540	-0.410
	(1.77)	(1.10)
Intermediates	0.108	0.222
	(3.04)**	(4.05)**
Non university labour	-0.117	-0.088
	(4.23)**	(0.75)
University labour	0.279	0.316
	(10.80)**	(5.80)**
High technology [b]	1.899	1.839
	(9.77)**	(6.79)**
High medium technology [b]	1.584	1.574
	(8.92)**	(7.07)**
Low medium technology [b]	1.018	0.941
	(5.67)**	(4.14)**
Constant	-5.856	-5.593
	(13.00)**	(8.29)**
Observations	90120	16636

Notes: The variables are in per employee terms and in logarithms. Absolute value of z statistics in parentheses. * significant at 5%; ** significant at 1%. (a) Reference alternative is Rest of Sweden. (b) Reference alternative is Low technology sector

Table 5. Summary descriptive statistics. Trade characteristics, in 1000 Euro

	1-10 Employees				11-25 Employees			
	All firms Obs 90,120		Patent applicants Obs 296		All firms Obs 16,636		Patent applicants Obs 199	
	Mean	*StD*	Mean	*StD*	Mean	*StD*	Mean	*StD*
Export share	3.1 %	*20.5*	13.0 %	*24.0*	10.5 %	*20.5*	31.5 %	32.1
Export products	0.8 %	*3.0*	3.3	*6.16*	3.8	*7.7*	9.6	*12.0*
Export destinations	0.7 %	*2.4*	3.0	*5.6*	3.4	*6.6*	11.7	*12.7*
Import share	5.3 %	*12.5*	5.6 %	*14.8*	5.3 %	*12.5*	7.3 %	*11.9*
Import products	0.8 %	*3.80*	2.6	*4.7*	4.1	*9.2*	7.1	*8.3*
Import origins	0.4 %	*1.28*	1.3	*2.0*	1.9	*3.1*	4.0	*4.3*
Export G7	3.3 %	*15.6*	19.2 %	*33.3*	10.9 %	*24.8*	27.7 %	*31.8*
Import G7	5.2 %	*20.8*	20.2 %	*36.4*	14.7 %	*30.2*	30.7 %	*37.6*

Table 6 Logit regressions. Determinants to apply for patents. Trade Characteristics

	1-10 emp	**11-25 emp**
Numbers of export destinations	0.036	0.046
	(3.55)**	(7.85)**
Fraction of export to G7	1.510	0.791
	(7.92)**	(3.25)**
Intermediates	0.091	0.217
	(2.59)**	(3.76)**
Non university labour	-0.144	-0.042
	(5.06)**	(0.35)
University labour	0.218	0.206
	(8.09)**	(4.11)**
High technology [b]	1.594	1.343
	(8.02)**	(4.75)**
High medium technology [b]	1.440	1.257
	(8.05)**	(5.52)**
Low medium technology [b]	1.016	0.822
	(5.68)**	(3.62)**
Constant	-6.381	-6.010
	(38.97)**	(15.46)**
Observations	90120	16636

Notes: The variables are in per employee terms and in logarithms. Absolute value of z statistics in parentheses. * significant at 5%; ** significant at 1%. (b) Reference alternative is Low technology sector

Table 7 Logit regressions. Determinants to apply for patents. Trade Characteristics

	1-10 emp	**11-25 emp**
Numbers of import origins	0.095	0.076
	(3.67)**	(4.38)**
Fraction of import from to G7	0.687	0.357
	(3.73)**	(1.68)
Intermediates	0.102	0.223
	(2.86)**	(4.00)**
Non university labour	-0.144	-0.099
	(5.06)**	(0.86)
University labour	0.231	0.249
	(8.54)**	(4.75)**
High technology [b]	1.657	1.502
	(8.34)**	(5.36)**
High medium technology [b]	1.461	1.410
	(8.17)**	(6.24)**
Low medium technology [b]	1.035	0.900
	(5.79)**	(3.97)**
Constant	-6.354	-5.832
	(38.62)**	(15.73)**
Observations	90120	16636

Notes: The variables are in per employee terms and in logarithms. Absolute value of z statistics in parentheses. * significant at 5%; ** significant at 1%. (b) Reference alternative is Low technology sector

APPENDIX

Table A Logit regressions. Determinants to apply for patents. Firm and export characteristics

	1-10 emp	**11-25 emp**
Numbers of export destinations	0.028	0.045
	(2.66)**	(7.20)**
Fraction of export to G7	1.371	0.724
	(7.14)**	(2.95)**
Sales	-0.192	-0.089
	(1.78)	(0.45)
Profit	-0.040	-0.073
	(1.44)	(1.87)
Intermediates	0.030	0.143
	(0.90)	(2.50)*
Equity	0.086	0.128
	(2.47)*	(2.15)*
Long term debt	0.086	0.069
	(4.48)**	(2.67)**
Short term debt	0.399	0.224
	(4.77)**	(1.64)
Non university labour	-0.126	0.032
	(4.22)**	(0.23)
University labour	0.186	0.180
	(6.76)**	(3.61)**
Domestic MNE [a]	0.444	0.005
	(1.88)	(0.02)
Foreign MNE [a]	0.525	-0.174
	(1.88)	(0.63)
Domestic UNI [a]	0.177	-0.104
	(1.12)	(0.59)
High technology [b]	1.591	1.391
	(7.91)**	(4.84)**
High medium technology [b]	1.339	1.223
	(7.46)**	(5.33)**
Low medium technology [b]	0.985	0.881
	(5.49)**	(3.83)**
Constant	-6.983	-6.565
	(17.77)**	(8.33)**
Observations	90120	16636

Notes: The variables are in per employee terms and in logarithms. Absolute value of z statistics in parentheses. * significant at 5%; ** significant at 1%. (a) Reference alternative is domestic non-affiliates. (b) Reference alternative is Low technology sector

Table B Logit regressions. Determinants to apply for patents. Firm and import characteristics

	1-10 emp	**11-25 emp**
Numbers of import origins	0.061	0.062
	(2.18)*	(3.29)**
Fraction of import from G7	0.604	0.331
	(3.27)**	(1.55)
Sales	-0.197	-0.047
	(1.81)	(0.24)
Profit	-0.036	-0.061
	(1.28)	(1.55)
Intermediates	0.039	0.144
	(1.17)	(2.63)**
Equity	0.088	0.155
	(2.54)*	(2.62)**
Long term debt	0.088	0.071
	(4.59)**	(2.78)**
Short term debt	0.389	0.151
	(4.62)**	(1.14)
Non university labour	-0.121	-0.002
	(4.04)**	(0.01)
University labour	0.200	0.217
	(7.28)**	(4.23)**
Domestic MNE [a]	0.536	0.168
	(2.26)*	(0.76)
Foreign MNE [a]	0.526	-0.016
	(1.89)	(0.06)
Domestic UNI [a]	0.201	-0.086
	(1.28)	(0.49)
High technology [b]	1.668	1.560
	(8.30)**	(5.48)**
High medium technology [b]	1.355	1.368
	(7.54)**	(6.00)**
Low medium technology [b]	0.990	0.929
	(5.52)**	(4.05)**
Constant	-6.901	-6.505
	(17.42)**	(8.41)**
Observations	90120	16636

Notes: The variables are in per employee terms and in logarithms. Absolute value of z statistics in parentheses. * significant at 5%; ** significant at 1%. (a) Reference alternative is domestic non-affiliates. (b) Reference alternative is Low technology sector.