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How to Persistently Finance Innovation: A Panel-Data Study on Exporting Firms in Sweden

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Abstract: This paper provides estimates of negative binomial regressions for high-leveraged and non-high-leveraged exporting firms in Sweden over a business cycle that contains two boom periods and two recession periods. The contemporaneous cash flow coefficients are positive and statistically significantly associated with patent applications for non-high-equity firms in recession periods when all exporters are considered. No corresponding correlation is found among persistent exporters. Taking the firms' geographical location into account, we find a significant difference in cash flow sensitivity between firms in metropolitan areas and firms located in other places.

Key words: Exporting, Innovation, Financing constraints, Firm level, Panel data
JEL classification: C16, F14, G32, O31

1. Introduction

We examine the fluctuation in innovation for exporting manufacturing firms in Sweden over the volatile time period of 1997-2010. We separate the sample into the recession periods of 2000-2002 and 2009-2010 and the rest of the period, which is mainly characterized by economic boost. Our primary interest is how a firm's innovative activity across the business cycle varies with capital structure, export frequency and geographical location.

Due to capital market imperfections, many firms face financing problems in economic downturns, and these problems are most severe for innovative firms. While the literature on innovative activity shows the advantages of innovation as a persistent and stable activity, firms' access to finance is typically volatile and highly affected by both cash flow and the supply of equity.

However, firms are heterogeneous, and Aghion et al. 2008 argue that financial problems give rise to the pro-cyclical pattern in innovative investments by constrained firms, whereas innovation follows a Schumpeterian cycle among non-constrained firms. Schumpeter (1942) considers recessions to be temporary drops of overall demand and an opportunity for firms to regroup and innovate. Thus, non-constrained firms can innovate in recessions and increase their competitiveness against financial constrained innovators and other firms.

In the analysis, we test financial constraints among the exporting firms by adopting the pecking order approach (Fazzari et al. 1988) behind innovation-cash flow sensitivity. We use patent applications as a proxy for innovation activity. We are aware that patents are not perfect measures of innovation. However, the use of patents as a measure of innovative activity is widely accepted (Lerner at al 2008). Moreover, both patent filings as well as R&D have historically moved in parallel with the development of Gross Domestic Product (OECD 2009, Griliches 1995).

Although investment-cash flow (ICF) sensitivity analysis composes a large body of literature in corporate finance and the theoretical literature predicts that innovation has intrinsic properties that make it difficult to finance externally (Arrow 1962, Hall 2002, Hall and Lerner 2010), empirical documentation on financial constraints among innovative firms constitutes a very limited selection of the literature (Brown and Petersen, 2011). This is particularly true

for systematic studies of populations with a large proportion of small firms observed in the form of panel data. In our study, the median firm has 30 employees and the mean is approximately 100. Moreover, our study makes several additional contributions to the literature. Only recently have economists started to investigate the links between credit constraints and exports (Wagner 2014), and this applies equally to the geography of innovation. Several studies suggest that financial constraints tend to decrease with geographical proximity; however, these predictions have been tested only to a very limited extent.

We hypothesize that the patenting strategy of firms with higher leverage should be adversely affected by a negative aggregate economic shock because of the fragility caused by having a great deal of debt (after controlling for other firm-specific factors). However, we assume that this sensitivity is reduced for persistent exporters and for firms located in metropolitan areas with closeness to various financial intermediaries and services.

Overall, our results suggest a new set of evidence on financial constraints and innovation among exporting firms. First, we show that there is a difference between firms depending on their capital structure. Second, we find a difference between exporters in general and firms operating persistently in foreign markets year after year. Finally, our regression results reveal a significant difference between firms located in metropolitan regions and firms located in other places.

The rest of this paper is organized as follows. In section 2, we provide a brief overview of the literature. Section 3 presents the data, defines the variables and reports descriptive statistics. Section 4 reveals the empirical approach. The results are reported in section 5, and section 6 concludes.

2. Background and motivation

The persistence of innovation plays an important role in explaining the persistence of firms' productivity and growth performance. An extensive body of literature suggests that persistent innovation efforts over the business cycle tend to create a self-enforcing effect, implying that profitable firms are able to better preserve their innovation activities due to both internal and

external financial resources (see Nelson and Winter 1982, Teece 2007, Cefis and Ciccarelli, 2005, Dosi and Nelson 2010, Griliches 1995, Geroski, van Reenen and Walters 1997, Hall (2007). Hence, firms that are capable of being persistent innovators develop internal capabilities are likely to be less sensitive to adverse macroeconomic shocks.

While persistent innovators constitute a self-selected group of firms, the literature identifies various groups of firms as credit-constrained and sensitive to negative demand shocks in their innovation engagement. Aghion et al. (2008) suggest that firms classified as credit-constrained have a pro-cyclical R&D share out of total investment, while non-constrained firms are able regroup and focus more heavily on innovation in recession periods. As a consequence, their innovation profile is counter-cyclical.

There are a number of studies documenting the financial effects on firm-level innovation. Investments in innovation are difficult to finance externally (Hall (2002) and Hall and Lerner (2010)) due to factors such as information asymmetries between firms and investors, skewed and highly variable returns to innovative projects, and the lack of collateral value.

In the present study, we partly confirm two groups of firms with different innovation engagement across the business cycle. The paper considers the relationships between exporters' innovative activity and economic fluctuations across a volatile time period. The period of focus begins with the economic boom of the late 1990s, it continues with the downturn related to the burst of the IT bubble in the early 2000s followed by the growth period after the IT debacle, and it ends with the financial crisis of 2009-2010.

In a previous study, Martinsson and Lööf (2013) find that patent applications among Swedish firms dropped substantially during the economic downturn, following the burst of the IT-bubble in the beginning of the 2000s, but that this downturn had little effect on the patenting activities of high-equity firms. The authors show that firms with the best supply of equity, other things equal, can maintain their patenting strategy over time, whereas firms with less equity experience drops in the number of patent applications when internal equity wanes. This paper takes the analysis further by considering (i) the presence in the export market, (ii) the persistent presence in the export market, and (iii) the effect of proximity.

In this paper, we separate our sample into two groups depending on their average equity ratio over the time period. The distinction is between firms in the top quartile and other firms. We test the importance of equity financing among exporters by adopting a pecking order approach behind innovation-cash flow sensitivity analyses first introduced by Fazzari et al. (1988). The prediction from this theory is that firms that benefit from a self-enforcing effect are less sensitive to reduced demand and variation in cash flow over time in their innovation activities. In contrast, financially constrained firms with less equity are sensitive to variation in cash flow in their innovation activities.

Using patent applications as a proxy for innovation engagement, in line with the global trend, patent filing among exporting firms in Sweden fell by approximately 25 percent during the 2000-2002 period and increased by more than 10 percent between 2003 and 2008. It is noteworthy that firms with moderate amounts of equity in relation to debt (1-3 quartiles in terms of leverage) account for the entire drop in patent applications following the economic downturn in the early 2000s. However, this distinction between equity groups is not present in the recession period of 2009-2010.

The decrease in patent applications during the first recession follows the predictions by the financing literature. Firms with relatively less equity are expected to be sensitive to adverse macroeconomic shocks. The decrease in applications during the financial crises that started at the end of 2008, however, are not linked to differences in firms' capital structure.

In one of the few previous studies that are similar to the present paper, Brown and Petersen 2009 explore the use of various sources of financing for R&D smoothing using longitudinal firm-level data from the U.S. The authors estimate an R&D-investment regression that include cash flow, new stock issues, and new debt issues as explanatory variables and report evidence of R&D smoothing for the firms that most likely to face credit frictions. No corresponding pattern could be found for firms that are less likely to be financially constrained.

Our motivation for restricting the analysis to exporting firms is that they account for the vast majority of the innovative activity in the economy, which is in line with the internal pattern. A growing body of empirical literature documents the self-selection of the most productive

firms in the export market, while there is conflicting evidence of the effect of exporting on future productivity (learning-by-exporting). The selection process might also be associated with innovation efforts. The theoretical prediction for the self-selection is that innovative firms with attractive products, efficient production technology, and high productivity become exporters (Grossman and Helpman 1995). Using micro-data, recent works provide empirical evidence of the interrelation between innovation and exports (for instance, Cassiman et al. 2010, Lileeva and Trefler, 2010, Aw et al. 2011).

Surveying the literature on financial credits and international trade, Wagner (2013) reports that the overall conclusion is that exporting firms are less financially constrained than non-exporting firms. In a corresponding manner, as productive and innovative are self-selected into exports, less financially constrained firms are self-selected into exporting firms. However, Wagner (2013) does not find any strong evidence in the literature that exporting improves financial health.

The literature provides various explanations for the positive correlations between firms' financial capacity and their ability to compete in foreign markets. The reasons include that international trade activities are often more risky than doing business with domestic firms and that export activities involve extra costs related to the entry into a foreign market that often have to be paid in advance. With weak financial conditions, firms might be prevented from entering the export market.

We also examine the relevance of geography to the relationship between business cycles and innovation. Several studies suggest that financial constraints tend to decrease with geographical proximity due to factors such as information advantage (Bae, Stulz, and Tan, 2008), board membership (Lerner 1995), closeness to other firms (Almazan et al. 2010, John and Kadyrzhanova, 2008, Gao et al. 2011), and different dividend policies (Kose et al. 2011). In the present study, we use the access to financial consultancies and other knowledge-intensive producers such as ICT services, engineering R&D and engineering services as a proxy for the mass or amount of influential external services in the local milieu. Based on the literature, we hypothesize that a favorable location may be able to compensate for a firm's financial constraints.

3. Data description

3.1 Data sample

The dataset is composed of several different sources. First, audited register information from the annual accounts of all firms in Sweden 1997-2010 is provided by Statistic Sweden (SCB). The second source is information on the educational background of all the employees in the firms observed. The third source is trade statistics for all manufacturing firms in Sweden over the same period. The final data source is patent statistics from the EPO Worldwide Statistical Database (PATSTAT) supplemented by national data from the Swedish Patent Office. In the merging process, we have managed to match 75% of the patent applications in PATSTAT. The data include information on all manufacturing firms with at least 10 employees in average over the observed period and with at least one year of experience in exporting.

We have made some restrictions for the construction of the dataset. First, we excluded all non-manufacturing firms because the trade data only cover the exports of goods. Second, because the trade data have some quality problems for the very small firms, we therefore exclude firms with an average number of workers below 10 during the sample period. Third, to be included in the sample, a firm must have exported for at least one year in the period we consider. Fourth, we also exclude firms with obvious erroneous observations. Following Brown et al. (2009), Fazzari et al. (1988) and Scellato (2007), all firms with negative sums of cash flow or total assets during the sample period are dropped. We also eliminate implausible values such as negative sales and equity figures, etc.[1] As a result, we end up with an unbalanced panel of 8,053 unique firms for the period 1997-2010. Approximately 15% of the exporting firms applied at least once for a patent during the sample period. Focusing on persistent exporters who exported during the whole period, we observe 2,443 unique firms. Among persistent exporters, 30% of the firms applied for a patent at least 1 year during this 14-year period.

We separate our sample into two groups based on their average equity ratio over the time period; firms in the top quartile are referred to as high-equity firms, and the rest are denoted as other firms. Moreover, we also split the sample based on their export activities. Those firms who have exported during all years are persistent exporters, and we report the descriptive statistics for them separately. In figure 1, it is clear that the patent profile during

[1] All of the financial variables are winsorized at the 1% level.

the first recession only dropped among non-persistent exporters. Persistent exporters display some annual variation but do not share in the development of all firms.

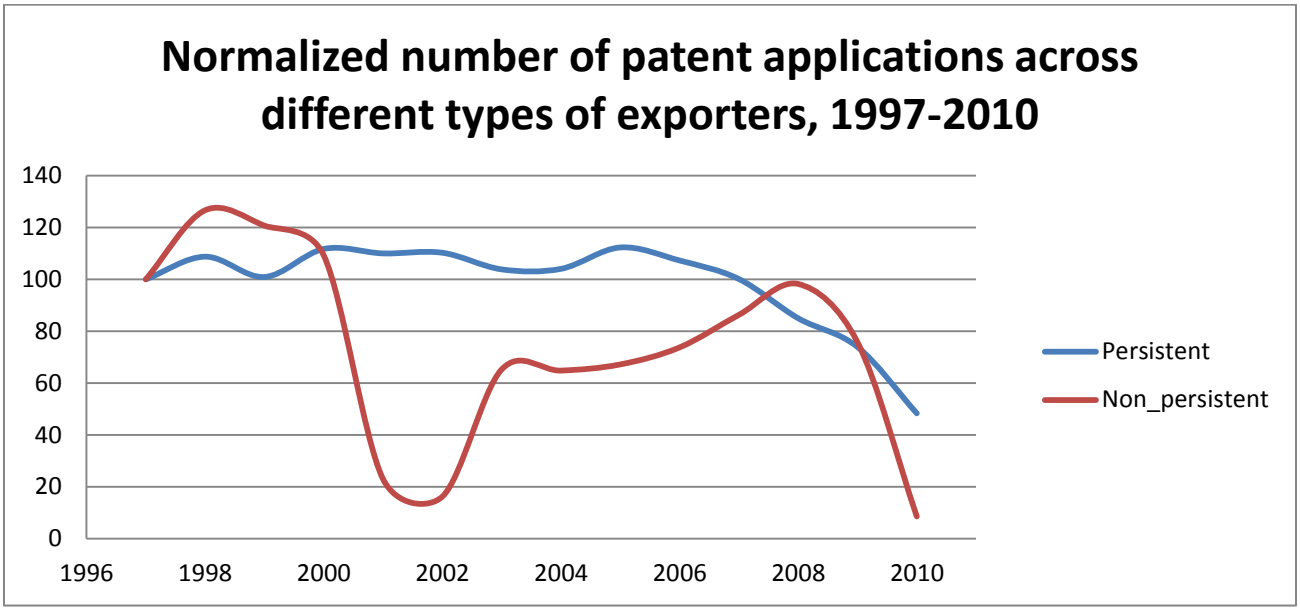

Figure 1 Number of patent applications across different types of exporters, 1997-2010.

Figure 2 presents the normalized total number of patent applications for high-equity firms and non-high-equity firms. It can be seen that the high-equity firms were also able to maintain their patent profile during the 2000-2002 recession and even increase it. Regarding the end of the period considered in the study, we observe a dramatic decline in the number of patent applications. This is partly explained by lagging information for the most recent periods in the PATSTAT, which assembles data from a large number of countries with different standards for reporting the applications. However, the reason for including the 2009-2010 financial crisis in the analysis is that we believe that there is no systematic pattern in the problem with the PATSTAT across firms and sectors.

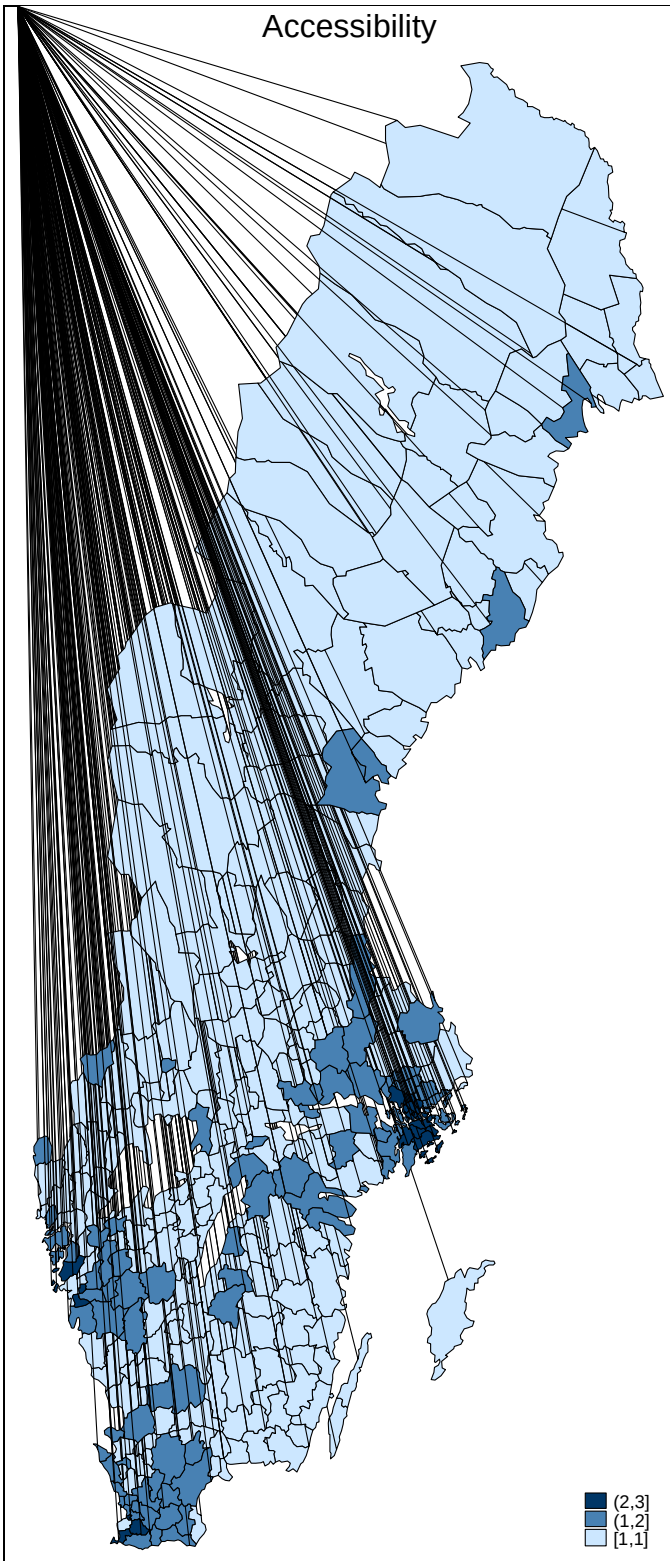

Figure 2 Access to financial services and other knowledge intense services in the 290 municipalities of Sweden. Dark: High access

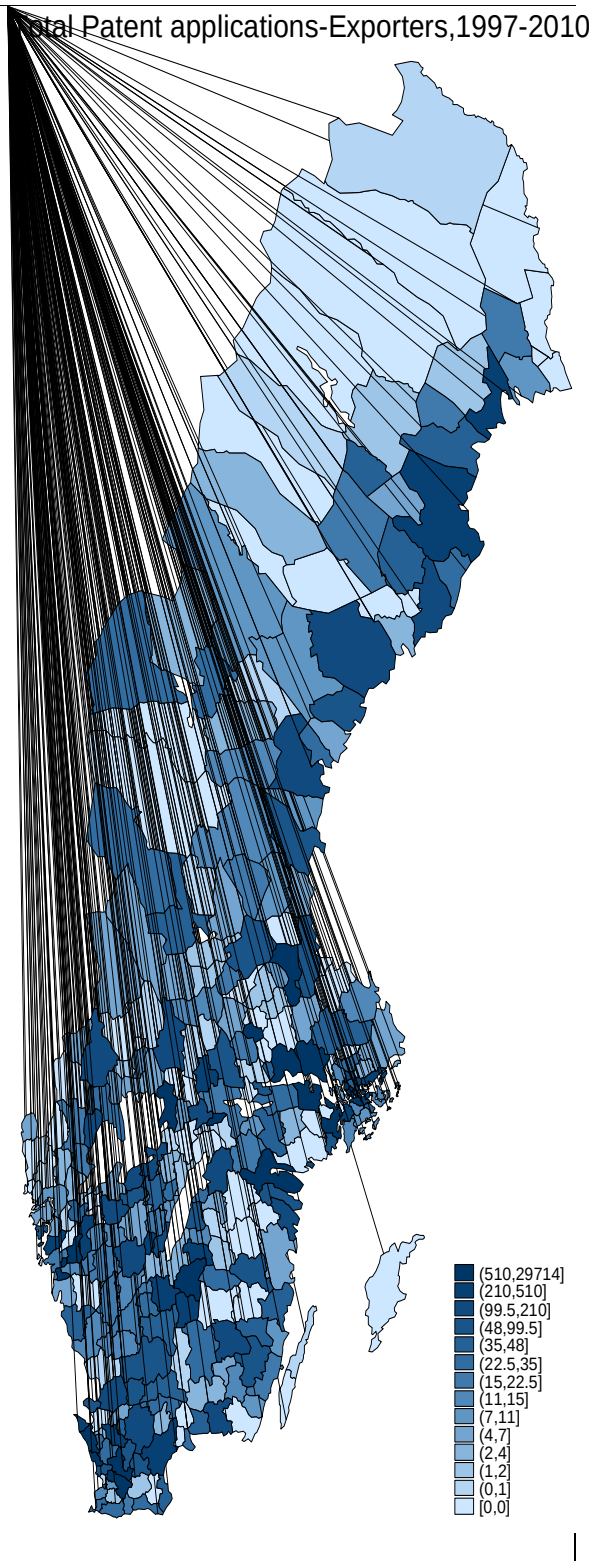

Figure 3 Patent applications among exporting firms during the 1997-2010 period. Dark: High application frequency

3.2 Relevance of geography

As we discussed above, recent studies argue that firms located in geographically proximate areas tend to be less constrained. One reason for this may be their closeness to financial markets and financial agents. The present paper considers this issue by separating the firms into three different categories depending on the extension of financial services and other producer-intensive services in their local milieu.

Figure 2 reveals our split of the 290 Swedish municipalities into three categories depending on their access to financial services and other knowledge-intensive services. The areas with the darkest marks are classified as high-access areas, while the areas with the brightest marks are classified as low-access areas. The remaining areas are classified as areas with medium access to external producer services. Not surprisingly, we find that the high-accessibility areas coincide with the three metropolitan areas of Stockholm, Gothenburg and Malmo, while a large fraction of the sparsely populated areas of Sweden may be considered as regions with limited access to specialized services.

In Figure 3, we use distribute all patent applications from 1997-2010 across Sweden, and here, we find a less clear pattern, but the general picture is still that the number of patents correlates strongly with population density.

Figures 4 and 5 illustrate the importance of incorporating the geographical dimension into our analysis. Figure 4 shows the development of patent applications across locations for high-equity firms, and Figure 5 shows the corresponding longitudinal frequency for other firms. While the pattern is almost the same for firms that belong to the non-high-equity group across the three categories of locations, the high-equity firms show a counter-cyclical Schumpeterian pattern during the IT recession, suggesting that the temporary drop of overall demand gives an opportunity to innovate. In contrast, the patent filings among other firms follow the pro-cyclical pattern suggested by Aghion et al. (2008). During the second recession of 2009-2010, however, no difference in the number of patent applications is found between the two categories of firms.

3.2 Summary statistics

Table 1 presents descriptive statistics for all exporting firms and all persistent exporters, respectively. Each group is also divided into high-equity firms and non-high-equity firms. Our main variable of interest is the number of *patent applications* of each firm in each year. We measure profitability by *Cash flow,* which is defined as net sales minus depreciation and amortization minus wage costs and material costs and gross investment and taxes divided by the total assets at the beginning of the period. *Sales* are the firms' net sales divided by the total assets at the beginning of the period. Firms' *Long-term debt* is also divided by the total assets at the beginning of the period. *Equity* is total equity divided by the total assets at the beginning of the period. We measure *employment* as the log values of total employees (the number of employees is reported in the descriptive statistics table). *Human capital* is the fraction of employees with at least 3 years of university education. We also have an ownership indicator, which distinguishes between non-affiliate members of a domestic group, a domestic multinational group and a foreign multinational group.

Following OECD-suggested classifications, we separate manufacturing firms into four broad sectors based on R&D and human capital intensity: high technology, medium-high technology, medium-low technology, and low technology.

No systematic difference can be observed among the high-equity and non-high-equity groups of firms. Concerning exporters with different equity ratios, high-equity firms are smaller and use less long-term debt on average. The high-equity group also has slightly higher human capital and a higher share of high-tech firms. A similar pattern can be found among persistent exporters.

Table 1 reports that approximately 50 percent of the firms in our study are located in low-access areas, barely 20 percent in high-access milieus and 1/3 of the firms in medium-access areas. The figures are approximately the same for firms with different equity ratios.

4. Empirical Approach

Our econometric model belongs to the count data family, as our dependent variable is the number of patent applications. Count data such as patent applications are often over-dispersed, and a common source is unobserved heterogeneity. The over-dispersion test

suggested by Cameron and Trivedi (2005) shows that the null hypotheses on equality between the mean and variance is violated for each of the samples. As a result, we consider the negative binomial regression method for our estimation, which accounts for over-dispersion. An alternative estimator is the Poisson estimator, which – when applied to patent data – usually suffers from both excess zero problems and over-dispersion; therefore, the negative binomial estimator is a better fit. However, the negative binomial model is less robust to distributional misspecifications compared to the Poisson model (Cameron and Trivedi (2005)). To improve the efficiency of the negative binomial estimator, we use the cluster-robust option (jackknife) to estimate the standard errors.

To investigate the importance of equity financing for patent activity, we adopt a pecking order approach. We specify the model as:

$$Q_{it} = \theta_0 + \theta_1 CF_{it} + \theta_2 CF_{it-1} + \theta_3 S_{it} + \theta_4 \Delta S_{it} + \theta_5 LTD_{it} + \theta_6 E_{it} + \theta_7 HC_{it} + \lambda_{it} + \omega_{it} + \eta_i + \nu_t \quad (1)$$

where Q_{it} denotes number of patent applications for firm i at time t, CF_{it} and CF_{it-1} are cash-flow and its lag, respectively, S_{it} is net sales for firm i at time t, and we also control for sales growth ΔS_{it}. Sales constitute a control for firm demand, which enables us to view the cash-flow estimate more as a sign of access to internal financing rather than a sign of high firm demand (Brown et al. (2009, p.163)). LTD_{it} is the long-term debt of firm i at time t. E_{it} refers to the log of the number of employees as a control for firm size and HC_{it} human capital for firm i at time t to control for knowledge within the firm. Cash flow, sales, and long-term debt are all normalized by the total assets in period $_{t-1}$. λ_{it} is the specific sector effect of which firm i belongs to in time t, ω_{it} is the specific effect of the ownership structure of firm i in time t, η_i is the firm-specific fixed effect, and ν_t is a time-specific effect.

In the second part of our study, we are interested in studying the potential of the access to external knowledge to explore the sensitivity of patent applications to the cash flow holdings of firms located in 3 different types of areas with respect to the external knowledge milieu. For this purpose, we add an interaction variable between the cash flow and the three groups of firms with low, medium and high levels of accessibility to knowledge.

$$Q_{it} = \theta_0 + \theta_1 CF_{it} * LA + \theta_2 CF_{it} * MA + \theta_3 CF_{it} * HA + \theta_4 CF_{it-1} + \theta_5 S_{it} + \theta_6 \Delta S_{it} + \theta_7 LTD_{it} + \theta_8 E_{it} + \theta_9 HC_{it} + \lambda_{it} + \omega_{it} + \eta_i + \nu_t \quad (2)$$

Where LA is a dummy variable equal to 1 if the municipality has low access to external knowledge, MA identifies municipalities with a medium level of access and HA represents municipalities with high external knowledge levels. It is worthwhile to note that the indicator variables LA, MA and HA for firm i are almost constant over the period we observe, as the firms' locations are almost constant. Both models also include the idiosyncratic error term.

For the dependent variable and most of the regressors, 70-90% of the variation in the data consists of the between variation rather than within. Applying the fixed-effects estimator, the coefficients of the time-invariant regressors are not identified, and a large fraction of the observations is dropped because there is no variation in y_{it} over t. The fixed-effects estimator is not very efficient because it relies on within variation, and we therefore use random-effects.

5. Econometric Analysis

In the econometric analysis, we explore how patent applications vary with cash flow across groups of firms with different capital structures over time. We do this in two different settings, first by the equity ratio in boom and recession periods and second by interaction terms for cash flow multiplied by low, middle and high access to financial services and other knowledge-intensive producer services in the firms' geographic locations. Two data samples are analyzed: all exporting firms and only persistent exporters. The majority (70%) of the firms are classified as non-persistent exporters.

Tables 2-5 report the regression results for exporting firms and persistent exporters, respectively, obtained from count data regressions using the negative binomial estimator. The structure of the tables is as follows. The left part of the tables provides estimates for high-equity firms, while the right part shows corresponding estimates for non-high-equity firms (other firms). Columns (i) and (iii) report the estimates for the periods 1997-1999 and 2003-2008 for the two categories of firms. Columns (ii) and (vi) display the results for the recession periods 2000-2002 and 2009-2010. Tables 2 and 3 provide the regression results based on equation (1), and Tables 4 and 5 show the results based on equation (2).

Starting with the results for all exporting firms displayed in Table 2, we first consider the dummy variable for persistent innovation (submitting patent applications for five years or

more). Blundell et al. (1995) show that not controlling for persistent innovation would cause a potential omitted variable bias in an econometric approach such as ours. The estimates are highly significant and sizable across all four columns, confirming the literature on internal spillovers between innovation processes over time. Moreover, following the previous literature, our motivation for splitting the data into two sub-samples is that we are only interested in comparing the two groups, so we assume that potential endogeneity biases linked to the co-determination of patent applications and equity similarly affect both groups of firms.

Patent applications are also related to the changes in long-term debt, firm size, human capital-intensity and industry technology level. The positive coefficient on long-term debt corroborates the pecking order theory and also suggests that access to credit is highly pro-cyclical. The results for persistent innovators, human capital and firm size are positive and statistically significant, and this pattern is consistent across all regressions in Tables 2-5. Concerning sales and sales growth, the results are insignificant in Table 2, but somewhat mixed across the 16 regressions in our analysis. The lag variable of cash-flow is positive and not significant among high-equity firms in bust periods. This finding is not applicable on high-equity firms in period preceding the regressions. In these cases, we consistently see strong correlation between cash flow and innovation (patent application) in the estimations. In the further analysis, we choose not to delve into any discussion of these control variables in our empirical model. The concentration is instead on the instantaneous cash flow variable.

Thus, our key interest is the cash flow variable based on the pecking order theory, and we expect that high-equity firms are less sensitive to variation in cash flow across the business cycle than other firms. This prediction is confirmed in Table 2. The estimated relationship between cash flow and patent applications is non-significant in both boom and recession periods among high-equity firms. In contrast and as we expected, exporters with non-high equity are sensitive to variations in cash flow. The negative binomial estimates show significant estimates only for the recession period.

Table 3 estimates equation (2) for all exporters, and our focus is the possible impact of the local milieu. Consider first the high-equity firms reported in columns (i) and (ii). The coefficients for the interaction variable cash-flow×location are significant different from zero or only weakly significant (location in areas with low access to external services). Thus, the results are consistent with the estimates for high-equity firms reported in Table 2.

In the last two columns of Table 3, we move from examining high-equity firms and instead look at the firms with moderate or low equity ratios. In this analysis, the results suggest that there is a difference between boom and recession periods, and the differences are related to firms located outside metropolitan areas. Looking first at the boom periods, the estimates for the key variables are all not significantly different from zero. However, in the recession periods, we see a distinct difference between firms in high-access areas and other firms (column iv). While the estimates are sizeable and significant for firms located in areas with low or medium access to external service producers, the estimate is close to zero and non-significant for firms in high-access areas. The conclusion here is that financial constraints have a clear geographical dimension. Our study indicates an important difference between metropolitan areas and other locations. Low-equity firms in the largest cities seem to be able to finance their innovation activities in recession periods from sources other than internal resources.

In Tables 4 and 5, we limit the analysis to using only firms that are persistently present in the export market year after year. In these regressions, effects due to financial constraints should be much less severe. This is also confirmed in Table 4. Estimating equation (2), no evidence of financial constraints is found among persistent exporters. This result applies for both high-equity firms and other firms.

While the previous literature has found that exporting firms are less financially constrained than non-exporting firms, our results suggest that persistent exporters are less financially constrained than other exporters. A possible explanation may be that persistent exporters can be considered as a select group, and the selection criterion is sufficient liquidity for not only entering both also remaining in foreign markets (Wagner 2014).

However, when we interact cash flow with the three geographical categories in Table 5, the results are similar to those reported for all exporters: the estimates of the interaction variables show that only high-equity persistent exporters in metro areas are unaffected by macro fluctuations. The recession estimates for other firms are quite sizable and significant at the 10% level or 5% level.

6. Conclusion

In this paper, we present evidence of the changes in innovative activities over the business cycle and relate these variations to the capital structure of exporting firms in Sweden. The research issue is important to examine for a number of reasons. Previous research suggests that financial constraints may hamper internal spillovers and knowledge accumulation within firms. Innovation activities have typical features of long-run investments (Lerner et al. 2008), and persistent innovation efforts over the business cycle creates a self-enforcing effect, implying that profitable firms and/or firms with access to external financing are able to better preserve their innovation activities; see Griliches 1995, Geroski, van Reenen and Walters 1997, Hall 2007, Dosi and Nelson 2010.

To explore the relationship between finance and innovation, we examine the behavior of patent applications in the two bust periods of 2000-2002 and 2009-2010 and the two boom periods of 1997-1999 and 2003-2008. While we are aware that the number of patents is not a perfect measure of innovation, the use of patents as a measure of innovative activity is widely accepted as a measure of the quality and extent of firms' innovations (Lerner et al. 2008).

Prior research reports that highly leveraged firms might be sensitive to negative macroeconomic shocks in their innovation engagement. Is this paper, we ask whether this pattern is also applicable to exporting firms, which are assumed to be a selected group of firms that are more innovative and productive than other firms. Moreover, we also examine the relevance of geography to the relationship between business cycles and innovation. Several studies suggest that financial constraints tend to decrease with geographical proximity.

Overall, our results suggest a new set of evidence of financial constraints and innovation among exporting firms. First, we show that there is a difference between firms depending on their capital structure. Second, we find a difference between exporters in general and firms operating persistently in foreign markets year after year. Finally, our regression results reveal a significant difference between firms located in metropolitan regions and firms located in other places. Considering all exporters, firms with moderate or high leverage are sensitive to variation in cash flows across the business cycle. Taking into account the geographical location of these firms, however, the financial constraints are concentrated on firms with low or medium equity ratios outside metropolitan areas. Regarding persistent exporters, we first

find no evidence of financial constraints. However, when the location is included into the analysis, it is shown that exporters in areas with low access to external financial services are sensitive to variations in cash flow in their innovation activities.

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Table section

Table 1: Summary statistics, Exporting manufacturing firms in Sweden, 1997-2010

		All exporters: 8,053		Persistent exporters: 2,443	
		High-Equity	Non-High-Equity	High-Equity	Non-High-Equity
Patent applications	Mean	1,837	6,216	620	1,823
	Median	0.344	1.420	0.489	2.153
	SD	(2.359)	(39.610)	(2.458)	(31.890)
Equity	Mean	0.654	0.268	0.676	0.310
	Median	0.621	0.237	0.656	0.291
	SD	(1.420)	(0.596)	(0.886)	(0.247)
Cash flow	Mean	0.509	0.578	0.502	0.548
	Median	0.472	0.531	0.457	0.507
	SD	(0.334)	(0.367)	(0.300)	(0.318)
Sales	Mean	2.006	2.339	1.880	2.187
	Median	1.835	2.132	1.760	2.038
	SD	(1.052)	(1.124)	(0.888)	(0.948)
Long-term debt	Mean	0.106	0.288	0.0897	0.259
	Median	0.0132	0.252	0.00686	0.230
	SD	(0.162)	(0.240)	(0.145)	(0.224)
Employment	Mean	57.45	116.5	69.29	175.6
	Median	25	28	32	43
	SD	(103.1)	(582.2)	(111.6)	(768.9)
Human capital	Mean	0.074	0.057	0.085	0.068
	Median	0.035	0.031	0.051	0.043
	SD	(0.139)	(0.096)	(0.115)	(0.090)
Sustainability					
Persistent innovator		0.073	0.046	0.123	0.104
Export experience		10.12	9.106	15.000	15.000
Accessibility					
High access		0.183	0.160	0.196	0.131
Medium access		0.335	0.347	0.33	0.330
Low access		0.494	0.502	0.46	0.539
Sector					
High-tech		0.094	0.059	0.117	0.065
Medium-High tech		0.278	0.272	0.306	0.337
Medium-Low tech		0.341	0.336	0.341	0.291
Low-tech		0.299	0.343	0.249	0.315
Ownership					
Foreign MNE		0.134	0.130	0.159	0.172
Domestic MNE		0.210	0.226	0.274	0.303
Domestic UNIE		0.308	0.327	0.275	0.288
Domestic NAE		0.349	0.319	0.292	0.237
Unique Firms		1837	6216	620	1823

Notes

Non-High-equity firms and high-equity firms are divisions based on equity ratios. We calculate the average equity ratio over the sample period, and the bottom 75% are in the "other firms" group, and the top 25% are in the high-equity group.

Cash flow, sales, long-term debt and equity are normalized by the total assets at the beginning of the period.

Human capital is the share of employees with at least 3 years of education as a fraction of total employment.

The sector classification is based on OECD's classification.

The four categories of ownership are Foreign MNE, Domestic MNE, Domestic enterprises belonging to a group with only domestic firms (Uninational, UNI), and Domestic non-affiliate enterprises (NAE).

Table 2: Patent applications of all exporting firms, non-recession and recession periods, 1997-2010.

VARIABLES	High-equity firms		Non-High-equity firms	
	Non-recession	Recession	Non-recession	Recession
Cash Flow	0.272	0.242	0.051	0.399**
	(0.286)	(0.261)	(0.164)	(0.185)
Cash Flow, lag	0.302	0.737***	0.096	-0.188
	(0.285)	(0.268)	(0.164)	(0.174)
Sales	-0.259**	-0.303***	-0.113*	-0.196***
	(0.103)	(0.109)	(0.060)	(0.065)
Sales growth	0.095	0.190*	-0.005	-0.012
	(0.103)	(0.107)	(0.063)	(0.066)
Long-term debt	0.506**	0.189	0.220	0.295*
	(0.239)	(0.310)	(0.157)	(0.165)
Employment, log	0.293***	0.340***	0.174***	0.206***
	(0.052)	(0.055)	(0.028)	(0.028)
Human capital	2.312***	1.792***	2.112***	1.698***
	(0.378)	(0.406)	(0.308)	(0.302)
Persistent Innovator	3.362***	2.838***	3.523***	3.477***
	(0.130)	(0.133)	(0.096)	(0.096)
High-tech	0.396**	0.346**	0.759***	0.786***
	(0.169)	(0.175)	(0.133)	(0.133)
Medium-high tech	0.310**	0.455***	0.577***	0.579***
	(0.147)	(0.141)	(0.099)	(0.097)
Medium-low tech	0.480***	0.428***	0.316***	0.219**
	(0.161)	(0.159)	(0.110)	(0.109)
Domestic MNE	0.136	-0.044	-0.207	-0.132
	(0.210)	(0.177)	(0.148)	(0.129)
Foreign MNE	0.620***	0.504***	0.485***	0.477***
	(0.190)	(0.133)	(0.132)	(0.094)
Domestic NAE	0.413**	0.686***	0.481***	0.414***
	(0.202)	(0.151)	(0.138)	(0.103)
Observations	7,494	7,354	21,764	21,461
Number of unique firms	1,624	1,627	5,336	5,318

Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Cash flow, sales, long-term debt and equity are normalized by the total assets at the beginning of the period. Human capital is the share of employees with at least 3 years of education as a fraction of total employment.

Table 3: Patent applications of all exporters, f**irms in different geographical locations** and during non-recession and recession periods, 1997-2010.

VARIABLES	High-equity firms		Non-High-equity firms	
	Non-recession	Recession	Non-recession	Recession
Cash Flow_low access	0.569*	0.324	0.189	0.516**
	(0.319)	(0.298)	(0.184)	(0.206)
Cash Flow_medium access	0.228	0.045	0.291	0.599***
	(0.295)	(0.297)	(0.187)	(0.201)
Cash Flow_high access	0.089	0.282	-0.210	0.060
	(0.327)	(0.272)	(0.192)	(0.221)
Cash Flow, lag	0.338	0.747***	0.076	-0.154
	(0.286)	(0.269)	(0.164)	(0.176)
Sales	-0.272***	-0.293***	-0.125**	-0.218***
	(0.105)	(0.110)	(0.060)	(0.065)
Sales growth	0.114	0.196*	-0.016	-0.008
	(0.105)	(0.108)	(0.063)	(0.066)
Long-term debt	0.549**	0.182	0.239	0.330**
	(0.241)	(0.311)	(0.158)	(0.165)
Employment, log	0.297***	0.337***	0.179***	0.207***
	(0.052)	(0.055)	(0.028)	(0.028)
Human capital	2.539***	1.793***	2.271***	1.887***
	(0.394)	(0.426)	(0.312)	(0.308)
Persistent Innovator	3.361***	2.845***	3.519***	3.486***
	(0.130)	(0.134)	(0.096)	(0.096)
High-tech	0.432**	0.377**	0.789***	0.806***
	(0.171)	(0.177)	(0.133)	(0.133)
Medium-high tech	0.305**	0.450***	0.568***	0.564***
	(0.148)	(0.141)	(0.099)	(0.097)
Medium-low tech	0.466***	0.418***	0.303***	0.188*
	(0.162)	(0.160)	(0.110)	(0.110)
Domestic MNE	0.141	-0.035	-0.205	-0.118
	(0.210)	(0.177)	(0.148)	(0.129)
Foreign MNE	0.623***	0.517***	0.472***	0.478***
	(0.190)	(0.133)	(0.131)	(0.094)
Domestic NAE	0.421**	0.695***	0.473***	0.416***
	(0.202)	(0.151)	(0.137)	(0.102)
Observations	7,494	7,354	21,764	21,461
Number of unique firms	1,624	1,627	5,336	5,318

Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Cash flow, sales, long-term debt and equity are normalized by the total assets at the beginning of the period.

Human capital is the share of employees with at least 3 years of education as a fraction of total employment.

Table 4: Patent applications of only persistent exporters, non-recession and recession periods, 1997-2010.

VARIABLES	High-equity firms		Non-High-equity firms	
	Non-recession	Recession	Non-recession	Recession
Cash Flow	-0.072	0.247	0.086	0.329
	(0.338)	(0.350)	(0.198)	(0.207)
Cash Flow, lag	0.390	0.807**	0.325*	-0.250
	(0.349)	(0.362)	(0.196)	(0.193)
Sales	-0.182	-0.254*	-0.202***	-0.092
	(0.138)	(0.149)	(0.076)	(0.077)
Sales growth	0.204	0.189	-0.009	-0.100
	(0.138)	(0.142)	(0.081)	(0.075)
Long-term debt	0.442	0.302	-0.010	0.172
	(0.307)	(0.426)	(0.188)	(0.190)
Employment, log	0.265***	0.240***	0.175***	0.218***
	(0.064)	(0.073)	(0.034)	(0.033)
Human capital	2.306***	1.296**	1.784***	1.697***
	(0.492)	(0.591)	(0.397)	(0.384)
Persistent Innovator	3.304***	2.713***	3.353***	3.354***
	(0.154)	(0.165)	(0.110)	(0.110)
High-tech	0.308	0.027	0.519***	0.684***
	(0.218)	(0.241)	(0.162)	(0.160)
Medium-high tech	0.027	0.260	0.627***	0.374***
	(0.183)	(0.187)	(0.124)	(0.118)
Medium-low tech	0.387**	0.267	0.440***	0.169
	(0.195)	(0.206)	(0.135)	(0.133)
Domestic MNE	-0.098	-0.073	-0.196	-0.039
	(0.245)	(0.227)	(0.184)	(0.157)
Foreign MNE	0.231	0.352**	0.151	0.461***
	(0.211)	(0.171)	(0.160)	(0.107)
Domestic NAE	-0.037	0.468**	0.062	0.390***
	(0.230)	(0.198)	(0.167)	(0.114)
Observations	3,230	3,179	9,530	9,421
Number of unique firms	600	605	1,777	1,779

Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Cash flow, sales, long-term debt and equity are normalized by the total assets at the beginning of the period.

Human capital is the share of employees with at least 3 years of education as a fraction of total employment.

Table 5: Patent applications of only persistent exporters, f**irms in different geographical locations**, non-recession and recession periods, 1997-2010.

VARIABLES	High-equity firms		Non-High-equity firms	
	Non-recession	Recession	Non-recession	Recession
Cash Flow_low access	0.176	0.157	0.272	0.408*
	(0.381)	(0.410)	(0.219)	(0.235)
Cash Flow_medium access	-0.084	-0.076	0.398*	0.562**
	(0.345)	(0.399)	(0.223)	(0.225)
Cash Flow_high access	-0.313	0.342	-0.413	-0.043
	(0.396)	(0.354)	(0.255)	(0.255)
Cash Flow, lag	0.434	0.880**	0.305	-0.228
	(0.348)	(0.366)	(0.195)	(0.195)
Sales	-0.201	-0.236	-0.219***	-0.118
	(0.141)	(0.150)	(0.077)	(0.078)
Sales growth	0.222	0.218	-0.034	-0.095
	(0.139)	(0.145)	(0.080)	(0.076)
Long-term debt	0.476	0.276	0.042	0.222
	(0.308)	(0.425)	(0.190)	(0.190)
Employment, log	0.264***	0.227***	0.182***	0.218***
	(0.064)	(0.074)	(0.034)	(0.034)
Human capital	2.542***	1.037	2.050***	1.873***
	(0.507)	(0.640)	(0.407)	(0.395)
Persistent Innovator	3.302***	2.738***	3.354***	3.366***
	(0.155)	(0.166)	(0.110)	(0.110)
High-tech	0.338	0.071	0.599***	0.703***
	(0.219)	(0.244)	(0.163)	(0.160)
Medium-high tech	0.039	0.248	0.637***	0.372***
	(0.184)	(0.188)	(0.124)	(0.118)
Medium-low tech	0.376*	0.267	0.447***	0.157
	(0.196)	(0.207)	(0.136)	(0.133)
Domestic MNE	-0.091	-0.073	-0.171	-0.014
	(0.245)	(0.227)	(0.184)	(0.157)
Foreign MNE	0.237	0.382**	0.142	0.459***
	(0.211)	(0.172)	(0.159)	(0.107)
Domestic NAE	-0.002	0.474**	0.049	0.381***
	(0.231)	(0.198)	(0.166)	(0.113)
Observations	3,230	3,179	9,530	9,421
Number of unique firms	600	605	1,777	1,779

Notes: Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Cash flow, sales, long-term debt and equity are normalized by the total assets at the beginning of the period.

Human capital is the share of employees with at least 3 years of education as a fraction of total employment.