CESIS Electronic Working Paper Series

Paper No. 194

Internal Finance and Patents
Evidence from firm level data

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Sept 2009

The Royal Institute of Technology
Centre of Excellence for Science and Innovation Studies (CESIS)
http://www.cesis.se

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Sept 6, 2009

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Abstract

We find that internal finance resources at the firm-level, measured by cash flow, play a non-trivial role for the number of patent applications, even after controlling for the standard variables of a patent study. The results are based on estimating panel count-data models on a sample of 2,700 Swedish manufacturing firms, with observations from the period 1997-2005. The cash-flow effect is larger during the aftermath of the bursting IT-bubble and for firms that are more likely to be financially constrained. Our results suggest that some firms reduce or stop applying for patents during periods of declining economic activity.

Keywords: Financing constraints; Innovation; Corporate ownership; Intellectual property rights, Firm level panel data

JEL: G32, O31, O34

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I. Introduction

In this paper we contribute to the knowledge of how a firm's financial resources affect its innovation activities. Considering how firms' patent applications are affected by their internal finance resources we find that cash-flow play a non-trivial role. This finding is in line with Schumpeter's (1942) contributions that internal finance is pivotal to the financing of innovation (see Hall, 2002 for a recent survey). The role of cash flow for the number of firm patent applications is pronounced for firms more likely to be financially constrained and during economic downturns such as during the aftermath of the bursting IT-bubble.

The results are based on a study of 2,700 manufacturing firms in Sweden, with observations from the period 1997-2005. Roughly 10 percent of the firms did at least once apply for a patent. The study applies panel-data negative binomial regression models which is preferred when the dependent variable contains many zeros.

The firm-level data used in this study is originally constructed from audited register information on firm characteristics based on annual reports of all firms in Sweden during 1997-2005. We have merged this data with additional data on the educational level of each firm's employees and national and international patents filed by enterprises in Sweden using the EPO Worldwide Statistical Database (PATSTAT)[3]. In the merging process we managed to match 76 percent of the firms in PATSTAT with unique firms in Sweden.

The abrupt end of the economic boom characterizing the second half of the 1990s is an example of a structural shock beginning in the IT-sector and which later on disrupted the overall economy. We focus on the cash-flow variable and investigate how the patenting activity by firms of different sizes, skill levels, technological intensities, ownership

[3] For a detailed information on PATSTAT, see http://wiki.epfl.ch/patstat

characteristics and external finance access is affected by external shocks altering the internal financing situation of firms. This study uses a corporate finance framework and relates business cyclicality and innovation through cash flow and patent applications. Our study is motivated due to the scarcity of work produced on financing and patenting.

The paper proceeds as follows. Section II describes the empirical strategy and our variables. Section III presents the data along the descriptive statistics. The econometric results are described in section IV and section V concludes.

II. Empirical strategy

A. Count and binary regression models

We use two measures of patent applications: (i) count-data reporting the number of patent applications by firm *i* in year *t*, and (ii) an indicator variable showing whether firm *i* has applied for a patent in year *t*. An application may have several applicants from different firms, motivating adjustment with weights. However, this requires assumptions of the particular contribution from each of the firms.

The general model is a firm-specific-effect model and may be expressed as:

$$y_{it} = \alpha_i + \mathbf{x}'_{\mathbf{it}}\boldsymbol{\beta} + \varepsilon_{it} \qquad (1)$$

where y_{it} denotes patent applications by firm *i* in year *t*, $\mathbf{x}_{\mathbf{it}}$ is a vector of regressors, α_i controls for firm-specific effects that may be fixed-effects (FE) or random-effects (RE), and ε_{it} an idiosyncratic error.

The literature suggests several alternative estimators for count-data estimations. The leading example is the negative binominal model (Cameron and Trivedi, 2008). Some of the standard complications in analyzing count data include the presence of unobserved heterogeneity due to omitted variables, an “excess” of zero observations and overdispersed data. We apply the panel-data negative binominal estimator accounting for both the overdispersed data and the unobserved firm-specific effects.

We also consider a logit firm-specific model with which we model the propensity of a firm applying for a patent. This binary model specifies that

$$\Pr(y_{it} = 1 \mid x_{it}, \beta, \alpha_i) = \Lambda(\alpha_i + x_{it}'\beta) \qquad (2)$$

where α_i may be an FE or RE and $\Lambda(z) = e^z(1+e^z)$

A crucial issue is whether the fixed-effects (FE) or the random-effects (RE) model is the appropriate model for our panel-data negative-binominal model. In the FE model, the unobserved firm-specific effects α_i in equation (1) are permitted to be correlated with the regressors $\mathbf{x}_{it}$. In the RE model it is assumed that α_i is purely random, implying that it is uncorrelated with the regressors. We find that the more relevant model for our data is the RE model. This estimator, which corrects for the panel-data complication that the observations are correlated over time for a given firm, makes it possible to estimate the coefficients of both time-invariant and time-varying regressors and can handle a large amount of zero observations of the dependent variables.

B. Variable selection

Our study is based on extensive firm characteristics on surviving and non-surviving manufacturing firms in Sweden during 1997-2005. To our knowledge, there are no similar studies on corporate finance and patent application activity at the firm level. The choice of variables to include is inspired by the more developed corporate finance and R&D investment literature (see Brown et al., 2009; Himmelberg and Petersen, 1994; Mulkaly et al., 2001). Fazzari et al. (1988) adopt a pecking-order approach (Myers and Majluf, 1984; Stiglitz and Weiss, 1981), and suggest that if a firm displays a high sensitivity of investment to cash-flow over time, it can be interpreted as a sign of financing constraints. We therefore consider firms displaying high sensitivities of patent applications to cash flow as being more financially constrained than others.

The dependent variable is *number of patent applications* and as a robustness model we estimate a logit-model with the dependent variable being 0 if firm *i* is not *applying for a patent* year *t* and 1 if they do. We wish to capture the impact of financial resources available internally to the firm on its patent application activity. The standard measure in the investment literature to capture internal finance capacity within the firm is *cash flow*. We construct the cash-flow variable from after-tax income plus depreciation and amortization. This is the explanatory variable which we devote most interest toward in the empirical study. We also include *sales* and *long-term debt* in the specification. Omitting the sales variable might contribute to the cash flow variable being overly emphasized in the econometric analysis. A firm's access to long-term debt is a factor which may reduce their cash-flow dependency, and thus failing to control for the impact of long-term debt may also lead us to miss-interpret the cash-flow estimate. These three variables are normalized by total assets in the beginning of the period.

We include a number of control variables in the regressions as well. *Human capital* is regarded as reflecting a firm's 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 changes the relative labor demand in favor of highly skilled and educated workers (e.g. Berman et al., 1998;

Machin and van Reenen, 1998). The variable human capital, number of employees with university education normalized by total number of employees, is one of the key variables when studying firm-level patenting activity.

We also control for firm *size*, which we measure in terms of the log of employment, which is important for at least two reasons. Our main regressions examine number of patent applications, and a large firm probably applies for more patents than a smaller firm, all else equal. Second, the theoretical literature suggests that the presence of asymmetric information and moral hazard problems may be particularly serious for small firms engaged in innovation activities. Thus, profitability and cash flow can be expected to be more important for small innovative firms, since they often have limited access to capital markets and difficulties in obtaining external funds. Large firms are expected to be less financially constrained on the capital market (see e.g. Almeida et al., 2004; Himmelberg and Petersen 1994; Gertler and Hubbard, 1989).

We account for the degree of *technology of the sector* the firm is operating in by assigning sectors in to four different classes. A typical argument in the neo-Schumpeterian literature is that the characteristics of a particular sector or industry with which a firm is affiliated may influence its innovation activity. Different sectors have different technology and innovation opportunities and are thus characterized by different technological regimes (Malerba and Orsenigo, 1993). Our empirical analysis includes sector dummies based on the sector's overall technology intensity. We consider four broad OECD classifications; high technology, high-medium technology, low-medium technology and low technology sectors.

We also add control variables for corporate ownership structure. We distinguish between individual firms and firms belonging to a corporate group. Our data permits us to distinguish between four types of corporate groups: (i) non-affiliate firm, (ii) uni-national corporations, (iii) domestically-owned multinational enterprises (MNE) and (iv) foreign-owned MNEs.

Following the literature, we assume there are important differences between non-MNEs regarding the sensitivity of innovation investment to fluctuations in financial resources (see Scherer, 1999; Pfaffermayr and Bellak, 2002; Klette and Kortum, 2004).

We also include year dummies to capture unobservable time-varying macroeconomic shocks common to all firms.

III. Data description and sample characteristics

A. Sample construction

The firm level data used in this study is originally constructed from audited register information on firm characteristics based on annual reports on surviving and non-surviving firms in Sweden during 1997-2005. We have merged this data with additional data on the educational level of each firm's employees and national and international patents filed by enterprises in Sweden using the EPO Worldwide Statistical Database (PATSTAT). In the merging process we managed to match 76 percent of the firms in PATSTAT data with unique firms in Sweden. Analyzing the remaining 24 percent of the patent applications shows that they mostly consist of micro firms with none or only a small number of employees, thus being irrelevant to our study.

The sample of this paper focuses on manufacturing firms exclusively. We do this for two particular reasons. Most of the patent applications in our sample are made by manufacturing firms. Moreover, a majority of studies on corporate finance and innovation involve exclusively manufacturing firms (e.g. Bond et al., 2003; Brown et al., 2009; Mulkaly et al., 2001). The present paper refers to this literature.

Since the data include the entire firm population in Sweden we are confronted with some unique data management issues. First, we must exclude firms with obvious erroneous observations. In line with Brown et al. (2009), Fazzari et al. (1988) and Scellato (2007), all firms with negative sums of cash flow-to-assets during the sample period are dropped. This reduces the variance within the firms in the sample. This procedure is particularly relevant in this study since we have data for all firms registered. Due to the many micro firms present in the sample we still face great variance in our sample, and in order to make the empirical analysis more relevant we exclude all firms with average employment below 10 during the sample period.

The key ratios; cash flow, sales and long-term debt are winsorized at the 10 percent level. Winsorizing at 10 percent is unusual, but due to the nature of our data we need to be strict in terms of excluding unrealistic values.[4] Even after these relatively strict sample construction constraints we have fairly high variance within our sample. Following the sample construction we end up with an unbalanced panel of about 2,700 firms during the period 1997-2005. About 10 percent of the firms have at least once applied for a patent during the sample period.

B. Descriptive statistics

[Table 1 about here]

This study focuses on relatively few variables. Our main explanatory variable is the cash-flow ratio. Table 1 displays summary statistics for the whole sample in columns 1-3 and for firms which have applied for at least one patent during the sample period in columns 4-6. The patent-applying firms are similar to the overall means and medians of the overall sample. The average cash-flow ratio of patenting firms is 0.065 compared to 0.054 for the overall sample.

[4] For instance Love (2003) and Baum et al. (2009) winsorize at the 2 percent level and Brown and Peterson (2009) at the 1 percent level.

The sales ratios of patenting firms are lower than for the overall sample, a feature which is visible in the empirical results through a negative sales-ratio coefficient.

There is large variability in the control variables we use. The human capital variable is 0.159 for the whole sample and 0.237 for the patenting firms. The patent applying firms are also larger expressed as the log of employment. In terms of sector belonging, 30 percent of the firms in the overall sample operate within low-technology sectors compared to only 13 percent for patenting firms. We also have data on ownership structure across firms. The firms are either owned by a foreign or domestic multinational enterprise (MNE), or is only operating within Sweden but has subsidiaries or is a subsidiary (we refer to those firms as uni-nationals), and finally there are the remaining firms which are categorized as non-affiliated. 35 percent of the firms in the overall sample belong to an MNE, foreign or domestic. However, among the patent applying firms the same figure is 68 percent. The share of non-affiliated firms among the patenting firms is only 15 percent compared to about 30 percent in the whole sample.

The affiliation of the firm is closely linked to the financing side of patenting as well as the size of the firm. A large firm is less likely to face binding financing constraints than a small firm (see e.g. Almeida et al., 2004; Gertler and Hubbard, 1989). Belonging to a group such as an MNE implies that potential financing troubles can be mitigated. It could be from additional funding from the mother company or because of the lower costs of obtaining external finance based on its affiliation (see for instance Hoshi et al, 1991), or the fact that firms acquired by MNEs are already successful firms. The descriptive statistics highlight that the control variables we use are relevant due to the differences between the overall sample and the patent-applying firms. We now proceed with formal econometric analysis in section IV.

IV. Econometric analysis

A. Baseline estimation results

[Table 2 about here]

Table 2 presents the count-data results of applying a negative binomial regression model to Swedish manufacturing firms. Column 1 contains the specification with only our financial variables. All three financial variables display large and statistically significant effects. Cash flow, our ratio of most interest, displays the largest parameter-estimate. In column 2 we add the control variables and examine how the cash-flow variable is affected. In column 5, when all the relevant factors are controlled for, cash flow is still significant and relatively large in size. The original estimate of cash flow in column 1 of 0.478 has dropped to 0.318. The increase of the p-value of cash flow in column 5, compared to column 1, indicates that we have large heterogeneity influencing the precision of the parameter-estimate. This is further explored with a battery of sample splits which are conducted in order to explore where, and to what extent, internal financing resources matter for firm-level patent applications.

[Table 3 about here]

Table 3 displays three relevant sample splits in order to examine the importance of cash flow to firms in different financial positions. The overall impression of the results in table 3 is that it is not the financial status measured as high cash reserves or large stocks of long-term debt that affects the sensitivity of firm-level patent applications to cash flow.[5] In column 6, small firms have a substantially larger cash-flow estimate than large firms, which is expected, albeit imprecisely estimated. Small firms are more likely to face financing constraints than large firms. A firm is considered small if it is below or at the median of average employment during the sample period.

B. Macro-effects and additional sample splits

[Table 4 about here]

We now move on to consider macro-related events affecting the sensitivity of patent applications to cash flow. Even though we include time-dummies in our regressions we still decompose the sample period in to distinct periods. The nature of the time period which our sample covers makes this decomposition relevant. In columns 1 and 2 we analyze the period 1997-2000 and 2001-2005 periods respectively. The first period covers the inflating of the IT-bubble which was a time when the Swedish economy grew rapidly. The second period covers the aftermath of the bursting IT-bubble and the later years of the second time period also include years with annual GDP-growth rates above 3 percent.

Interestingly, we see no financial effects from cash flow or long-term debt in column 1, i.e. during 1997-2000. This was a period when expectations regarding high-tech and innovation were very high and lots of seed money and venture capital was readily available which relaxed otherwise binding financing constraints. Applying the rationale behind cash-flow sensitivities, this is a plausible explanation to the non-significant cash flow estimate for 1997-

[5] The cash sample split is based on the cash and short-term investment variable. A firm is considered in the high cash sample if it is above the median in terms of average cash holdings during the sample period. The same is conducted for the long-term debt sample split.

2000. However, the size estimate is almost twice as large for the 1997-2000 sample than for the 2001-2005 sample. The cash-flow estimate of the 2001-2005 is economically as well as statistically significant. This implies a rising sensitivity of patent applications to cash flow during the aftermath of the bursting IT-bubble. One reason for the difference in cash flow sensitivity might be that after the IT-bubble there was an increase in risk aversion which made additional funding sources, other than internal finance, scarcer. The size estimate, mentioned above is also relevant. The size estimate of the 2001-2005 period is half the size as it was in 1997-2000 implying that the increased sensitivity of patenting to cash flow could simply reflect that smaller firms were by then applying for patents. We have also examined the period 1998-2002 in order to see if including both the building-up and the bursting phase in the same sub-sample contained any additional evidence (following Brown and Peterson, 2009). Based on the results of columns 1-3 in table 4 it appears to be mostly relevant to look into the expanding 1997-2000 phase and the aftermath phase of 2001-2005 rather than to explore 1998-2002.

Table 4 also displays sample splits based on firm-affiliation. In line with the expectations of financing constraints and patents MNE-affiliated firms do not display sensitivity of patent applications to cash flow. In column 6 of table 4 we examine non-affiliated firms separately. This sub-sample produces the by far largest cash flow-sensitivity, albeit only with a p-value of 0.06. The results of the sample of uni-national firms are similar to the MNE-estimates. The separation of firms based on their corporate ownership structure confirms the story of sensitivity of patent applications to cash flow.

C. The propensity to apply for a patent

[Table 5 about here]

In order to check the robustness of our results we estimate the same baseline regression model as in table 2 but with another dependent variable. In this section we estimate a logit-model with the dependent variable being 0 if firm *i* is not applying for a patent year *t* and 1 if they do. Column 1 shows a clear and large sensitivity of the propensity to apply for a patent to cash flow. The point estimate is twice as large as in the count-data baseline model of table 2. The cash-flow estimate displays a similar development as in table 2 with the count-data model. When we add all control variables the cash-flow estimate decreases somewhat in size and also in precision. By examining the propensity to apply for a patent as well we learn that the impact of cash flow is not only important to the number of patent applications.

V. Conclusion

We estimate count data regression models for manufacturing firms in order to examine the impact of internal finance capacity on firm-level patenting activity. Internal finance capacity is measured by cash flow. As dependent variable we use the number of patent applications per firm and year.

The study mainly concerns evaluating the impact of cash flow on the number of patent applications. The results are robust to considering the propensity to apply for a patent. We find that cash flow plays a non-trivial role in determining the number of patent applications at the firm-level. The baseline regression controls for firm-size, human-capital intensity, the technology level of the sectors, and firm affiliation. We also include the stock of long-term debt and sales, and the regression models are applied to a sample of manufacturing firms in Sweden in 1997-2005. The results show that firms patenting activity is highly sensitive to variation in cash-flow.

Our data allows us to examine a booming economy separately from a contracting one. This makes our study unique since we analyze how exogenous shocks affect firm-level patenting.

We, therefore, examine the sub-sample 1997-2000, the build-up of the IT-bubble, separately, from 2001-2005, the aftermath of the bursting IT-bubble. During 1997-2000 the sample displays no sensitivity of patent applications to cash flow, a sign that firms are not constrained based on internal finance resources. In contrast, in the 2001-2005 sample, there is a large and statistically significant cash flow effect implying that when overall economic activity declines firms are more dependent on internal finance. Adding to this image, firms affiliated to an MNE, display no cash-flow sensitivity whereas non-affiliated firms display much higher sensitivity of patent applications to cash-flow than for the overall sample.

Our results contain important implications. The cash-flow sensitivity, a sign of financing constraints, is present during times of low economic activity (2001-2005) and for firms with less access to external finance (non-affiliated firms). Therefore, during extended periods of low economic activity and the subsequent risk aversion in the financial market might cause some categories of firms to reduce or stop applying for patents. This in turn could potentially hurt the long-term economic development of a country.

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Table 1 - Summary statistics for manufacturing firms during the period 1997-2005

	All firms 12,368 observations			Patenting firms 2,370 observation		
	Mean	Median	Std dev	Mean	Median	Std dev
Cash flow	0.051	0.030	0.096	0.060	0.037	0.105
Sales	2.295	2.170	1.092	1.932	1.994	0.993
L debt	0.250	0.206	0.229	0.247	0.204	0.232
Log size	3.507	3.218	1.192	4.251	4.051	1.450
Human cap	0.159	0.120	0.152	0.214	0.173	0.144
HT	0.068	0.000	0.253	0.088	0.000	0.285
HMT	0.321	0.000	0.466	0.509	0.000	0.500
LMT	0.321	0.000	0.467	0.274	0.000	0.447
NAF	0.297	0.000	0.457	0.121	0.000	0.326
UNINAT	0.341	0.000	0.474	0.183	0.000	0.387
FMNE	0.121	0.000	0.106	0.229	0.000	0.428
DMNE	0.239	0.000	0.426	0.458	0.000	0.498

Notes

Cash flow, sales and long terms debt are normalized by beginning of the period total assets.
Size is log employees.
HT is high technological firms, HMT is high median technology firms, LMT is low median technology firms.
Hum cap is number of employees with at least 3 years of education as a fraction total employment.
UniNat is a uninational corporations i.e. firms only operating domestically but may have or be a subsidiary. FMNE and DMNE are foreign and domestic multinational enterprises respectively. The intercept represents non-affiliated firms.

Table 2 - Negative binominal regressions: Baseline regression results

	(1)	(2)	(3)	(4)	(5)
Cash flow	0.478	0.459	0.425	0.318	0.318
	(0.029)**	(0.033)**	(0.035)**	(0.046)**	(0.056)*
Sales	-0.369	-0.392	-0.333	-0.253	-0.230
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
L debt	0.300	0.330	0.458	0.351	0.318
	(0.003)***	(0.001)***	(0.000)***	(0.000)***	(0.001)***
Log size			0.315	0.363	0.317
			(0.000)***	(0.000)***	(0.000)***
HT [a]			1.187	1.002	0.961
			(0.000)***	(0.000)***	(0.000)***
HMT [a]			0.874	0.866	0.841
			(0.000)***	(0.000)***	(0.000)***
LMT [a]			0.971	0.997	0.910
			(0.000)***	(0.000)***	(0.000)***
Human cap				2.728	2.601
				(0.000)***	(0.000)***
UNINAT [b]					-0.126
					(0.473)
FMNE [b]					0.443
					(0.012)**
DMNE [b]					0.656
					(0.000)***
Observations	12874	12874	12832	12768	12768
Unique firms	2695	2695	2693	2672	2672

Notes

Dependent variable is number of patent applications
*** significant at 1%; ** significant at 5%; * significant at 10%.
p values in parentheses.
Cash flow, sales and long terms debt are normalized by beginning of the period total assets.
Size is log employees.
HT is high technological firms, HMT is high median technology firms, LMT is low median technology firms.
Hum cap is number of employees with at least 3 years of education as a fraction total employment.
UniNat is a uninational corporations i.e. firms only operating domestically but may have or be a subsidiary. FMNE and DMNE are foreign and domestic multinational enterprises respectively. The intercept represents non-affiliated firms.
(a) Reference is low technology firms
(b) Reference is domestic non-affiliate firms

Year dummies included.

Table 3 – Negative binominal regressions: Sample splits on the level of cash reserves, level of long-term debt and firm size

	(1)	(2)	(3)	(4)	(5)	(6)
	High cash flow	Low cash flow	High debt	Low debt	Large firms	Small firms
Cash flow	0.525	0.209	0.395	0.322	0.301	1.251
	(0.145)	(0.275)	(0.074)*	(0.187)	(0.091)*	(0.094)*
Sales	-0.127	-0.257	-0.341	-0.132	-0.278	-0.223
	(0.121)	(0.000)***	(0.000)***	(0.036)**	(0.000)***	(0.027)**
L debt	0.178	0.348	0.291	0.316	0.283	0.500
	(0.313)	(0.002)***	(0.005)***	(0.148)	(0.005)***	(0.124)
Log size	0.379	0.338	0.298	0.446	0.300	0.468
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.061)*
HT [a]	0.595	1.176	1.236	0.854	0.825	1.552
	(0.098)*	(0.000)***	(0.000)***	(0.008)***	(0.001)***	(0.001)***
HMT [a]	0.807	0.901	1.048	0.537	0.753	1.403
	(0.012)**	(0.000)***	(0.000)***	(0.054)*	(0.000)***	(0.000)***
LMT [a]	0.823	1.009	1.020	0.738	0.919	0.936
	(0.006)***	(0.000)***	(0.000)***	(0.009)***	(0.000)***	(0.013)**
Human cap	2.284	2.850	2.955	1.694	2.611	2.998
	(0.001)***	(0.000)***	(0.000)***	(0.002)***	(0.000)***	(0.000)***
UniNat [b]	0.106	-0.307	-0.365	0.487	-0.120	-0.463
	(0.698)	(0.182)	(0.074)*	(0.143)	(0.645)	(0.080)*
FMNE [b]	1.159	0.049	0.164	1.062	0.397	0.411
	(0.001)***	(0.808)	(0.414)	(0.002)***	(0.074)*	(0.361)
DMNE [b]	1.078	0.338	0.377	1.304	0.595	0.005
	(0.001)***	(0.062)*	(0.029)**	(0.000)***	(0.004)***	(0.987)
Observations	5380	7388	8519	4249	6470	6298
Unique firms	1253	1419	1515	1157	1320	1352

Notes

Dependent variable is number of patent applications
*** significant at 1%; ** significant at 5%; * significant at 10%.
p values in parentheses.
Cash flow, sales and long terms debt are normalized by beginning of the period total assets.
Size is log employees.
HT is high technological firms, HMT is high median technology firms, LMT is low median technology firms.
Hum cap is number of employees with at least 3 years of education as a fraction total employment.
UniNat is a uninational corporations i.e. firms only operating domestically but may have or be a subsidiary. FMNE and DMNE are foreign and domestic multinational enterprises respectively. The intercept represents non-affiliated firms.
(a) Reference is low technology firms
(b) Reference is domestic non-affiliate firms

Year dummies included.

Table 4 – Negative binominal regressions: Sample splits on business cyclicality and firm affiliation

	(1)	(2)	(3)	(4)	(5)	(6)
	1997-2000	2001-2005	1998-2002	MNE	UniNat	Non-Affiliated
Cash flow	0.022	0.714	0.385	0.250	1.368	2.884
	(0.858)	(0.004)***	(0.017)**	(0.163)	(0.166)	(0.068)*
Sales	-0.292	-0.238	-0.274	-0.251	-0.211	-0.267
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.099)*	(0.036)**
L debt	-0.004	0.253	0.220	0.280	0.282	0.598
	(0.984)	(0.012)**	(0.212)	(0.006)***	(0.519)	(0.206)
Log size	0.781	0.465	0.416	0.312	0.832	0.893
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
HT [a]	0.841	1.799	0.950	0.846	1.571	2.025
	(0.004)***	(0.000)***	(0.000)***	(0.001)***	(0.001)***	(0.003)***
HMT [a]	0.763	1.335	0.862	0.633	1.594	1.579
	(0.002)***	(0.000)***	(0.000)***	(0.004)***	(0.000)***	(0.001)***
LMT [a]	0.925	1.027	0.891	1.041	0.864	1.444
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.860)	(0.002) ***
Human cap	2.983	2.863	2.659	2.556	0.502	3.601
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.652)	(0.000)***
UniNat [b]	-0.691	0.004	-0.357			
	(0.005)***	(0.987)	(0.084)*			
FMNE [b]	0.101	0.465	0.408			
	(0.587)	(0.045)**	(0.039)**			
DMNE [b]	0.281	1.049	0.577			
	(0.066)*	(0.000)***	(0.001)***			
Observations	5048	7720	8290	4610	4357	3801
Unique firms	2184	2246	2425	1120	1082	1084

<u>Notes</u>

Dependent variable is number of patent applications
*** significant at 1%; ** significant at 5%; * significant at 10%.
p values in parentheses.
Cash flow, sales and long terms debt are normalized by beginning of the period total assets.
Size is log employees.
HT is high technological firms, HMT is high median technology firms, LMT is low median technology firms.
Hum cap is number of employees with at least 3 years of education as a fraction total employment.
UniNat is a uninational corporations i.e. firms only operating domestically but may have or be a subsidiary. FMNE and DMNE are foreign and domestic multinational enterprises respectively. The intercept represents non-affiliated firms.
(a) Reference is low technology firms
(b) Reference is domestic non-affiliate firms

Year dummies included.

Table 5 – Logit regression models: Baseline regression results

	(1)	(2)	(3)	(4)	(5)
Cash flow	1.074	1.227	1.225	1.086	0.967
	(0.047)**	(0.025)**	(0.031)**	(0.059)*	(0.092)*
Sales	-0.483	-0.491	-0.429	-0.351	-0.321
	(0.000)***	(0.000)***	(0.000)***	(0.000)***	(0.000)***
L debt	0.668	0.609	0.799	0.744	0.679
	(0.006)***	(0.012)**	(0.002)***	(0.003)***	(0.007)***
Log size			1.383	1.333	1.198
			(0.000)***	(0.000)***	(0.000)***
HT [a]			2.360	1.858	1.818
			(0.000)***	(0.000)***	(0.000)***
HMT [a]			2.251	2.199	2.130
			(0.000)***	(0.000)***	(0.000)***
LMT [a]			1.397	1.555	1.485
			(0.000)***	(0.000)***	(0.000)***
Human cap				4.149	3.754
				(0.000)***	(0.000)***
UniNat [b]					-0.081
					(0.752)
FMNE [b]					0.713
					(0.016)**
DMNE [b]					0.770
					(0.003)***
Observations	12874	12874	12832	12768	12768
Unique firms	2695	2695	2693	2672	2672

Notes

Dependent variable is 1 if firm applied for at least one patent year t and 0 otherwise
*** significant at 1%; ** significant at 5%; * significant at 10%.
p values in parentheses.
Cash flow, sales and long terms debt are normalized by beginning of the period total assets.
Size is log employees.
HT is high technological firms, HMT is high median technology firms, LMT is low median technology firms.
Hum cap is number of employees with at least 3 years of education as a fraction total employment.
UniNat is a uninational corporations i.e. firms only operating domestically but may have or be a subsidiary. FMNE and DMNE are foreign and domestic multinational enterprises respectively. The intercept represents non-affiliated firms.
(a) Reference is low technology firms
(b) Reference is domestic non-affiliate firms

Year dummies included.