Master Thesis in Finance

Department of Business Administration

R&D, Investments, and Financial Constraints: Empirical Evidence from Swedish Manufacturing Firms

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ABSTRACT

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Background: Innovation is the key factor of economic growth. Investment in innovation is largely emphasized throughout the world. Sweden has been quite successful in developing high technology and has almost the highest R&D expenditure in terms of its GDP during the recent decade. Due to business practice, issues such as information asymmetry and agency problems hinder firms from raising external funds freely. However, certain financial systems such as the "bank-based" system in Germany and Sweden were believed to help firms with accessing to bank loans. In the recent years, due to globalization, Sweden is believed to switch from its "bank-based" system to a more market-oriented system like in the UK and US.

Purpose: In this paper, I study a panel of Swedish manufacturing firms during 1998 and 2007. I mainly focus on three questions, whether the Swedish firms are restricted to internal earnings for R&D investment; what are the factors that possibly affect the R&D investment; and whether they differently affect investment in R&D and investment in plant, machinery, and equipment.

Method: Dynamic panel regression model is applied to the study.

Results: The result shows that Sweden still remains a "bank-based" financial system. Therefore, most of its firms are not restricted to internal earnings during this period. In addition, the stock market also provides large investment opportunities for the firms to develop their R&D.

Keywords: cash flow, financial constraints, R&D, bank-based system, market-based system

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CHAPTER 1: INTRODUCTION

How do firms make decisions on financing their investment activities? According to market imperfection theories, firms prefer using internally generated cash flow (retained earnings) than raising external funds due to asymmetric information, agency problem, taxation, and so forth (see e.g. Jensen, 1986). This has been supported by evidence and well documented by a large number of empirical studies. Hubbard (1998) observed a positive correlation between firms' investment in fixed capital and the availability of their internal funds. Fazzari, Hubbard, and Petersen (1988) analyzed a panel of US Manufacturing firms and concluded that young firms were more dependent on internal financing than mature firms. The studies of Hadlock (1998) and Pawlina and Renneboog (2005) found that the sensitivity of firms' investment to internal funds was largely due to agency problem that management tends to squander extra cash flow on unprofitable projects.

Unlike the above studies on fixed capital investment, I am more interested in how the situation would be when firms invest in high technology, research and development (R&D). Why look at R&D? It is because R&D is a unique type of investment. It usually involves long research period, uncertain outcomes, high-risk of return, and it is often very hard for non-professionals to evaluate it. In addition, the information on research and development projects is seldom exposed to outsiders because high competition among the high-tech firms prevents knowledge spillover (Aboody and Lev, 2000). Thus, intuitively it would be very hard for these firms to raise external funds, even harder than those for fixed capital investment. Therefore, the high-tech firms are usually highly dependent on their internal funds, on venture capitalists, or on stock market. Some studies on American high-tech firms observe a strongly positive relationship between the investments in knowledge intensive activities and cash flow (see e.g. Himmelberg and Peterson, 1994). Some other studies have done a comparison on the Anglo-Saxon and European continental countries. They found that the firms in the continental countries are less constrained to cash flow than the American firms. This is due to the different national financial systems in the two groups. The financial systems in the European countries (except the UK and Netherlands) are more protective towards creditors. Banks build relationships with industry to help firms in taking loans. By contrast, the American financial system is more market oriented which the investors' behaviors are more dependent on the overall movement of the market (see e.g. Bond, Harhoff, and Reenen, 1999).

The novelty of this thesis is that I focus on the situation of the investment in R&D of the Swedish firms, which has not been studied before. The reason for choosing Sweden as the target of study is that Sweden is among the world's most innovative countries (along with Finland and Japan). It is thus very interesting to see how the Swedish firms make their investment decisions under such innovative environment.

In this thesis I address the following three questions: Are Swedish firms constrained to their internal cash flow when investing in R&D activities? Are there any other factors (such as firm size, ability to take bank loans and issuing stocks) that also influence firms' investment in R&D? Lastly, is there any difference in investing in R&D and in fixed capital (machinery and equipment) as the latter is more certain with future return?

My main hypotheses were that cash flow should correlate with R&D investment (for small firms) and with fixed assets investment (for large firms), that ability to raise debt should correlate with fixed assets investments, and that indicators of investment opportunity should correlate with both R&D and fixed assets investment.

I tested the hypotheses on a sample of 154 Swedish manufacturing firms listed on the Stockholm Stock Exchange (OMX), over the period of 1998 – 2007. There were two reasons for selecting this time frame. Firstly, this period contained a sufficiently large amount of data available for my test. Secondly, in the late 90s due to the fast development of computer technology, it appeared the "Dot-com bubble" in the stock market world wide. I used the dynamic panel regression method on conducting the analysis.

The main findings of the study were that R&D investment were most influenced by investment opportunity (especially the Tobin's Q measure), whereas fixed assets investment correlated with cash flow as well as ability to raise long-term debt. This suggests that Swedish firms do not operate in a market environment similar to Anglo-Saxon countries, where significant positive relation between cash flow and R&D investment was found.

The remainder of this thesis is organized as follows. Section 2 gives a brief overview of the Swedish R&D situation in the world scale. Section 3 reviews the theories and previous empirical studies. Section 4 introduces the hypotheses, data, and methodology. Section 5 presents the main results and implications. Section 6 discusses the results and links them to a broader perspective. In the end, I summarize the study and give perspectives for future research.

CHAPTER 2: SWEDEN IN THE WORLD'S POSITION

Sweden's GDP growth has been above the OECD average in the recent years. This is largely due to the intensive investment in technology. Sweden's R&D expenditure was approximately 3.73% of GDP in 2006, well above the OECD average of 2.2%. Sweden was at the leading position in R&D investment, together with Finland, Japan and Korea. The main financing source of the R&D comes from business sector which accounts for 2.79% of the GDP in 2006 (see OECD ST&I Outlook 2008). **Chart 1** illustrates the gross domestic R&D expenditure of different OECD countries in 2007. **Chart 2** shows the R&D expenditure coming from the business sector among the Scandinavian countries between 1996 and 2006.

Chart 1. Gross domestic expenditure on R&D as a percentage of GDP

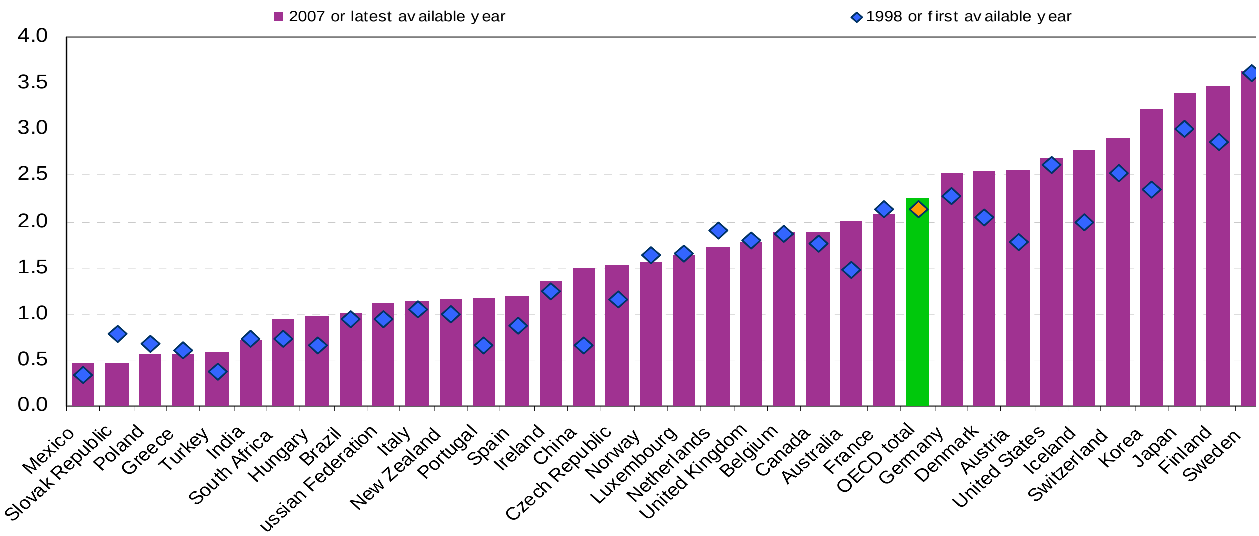
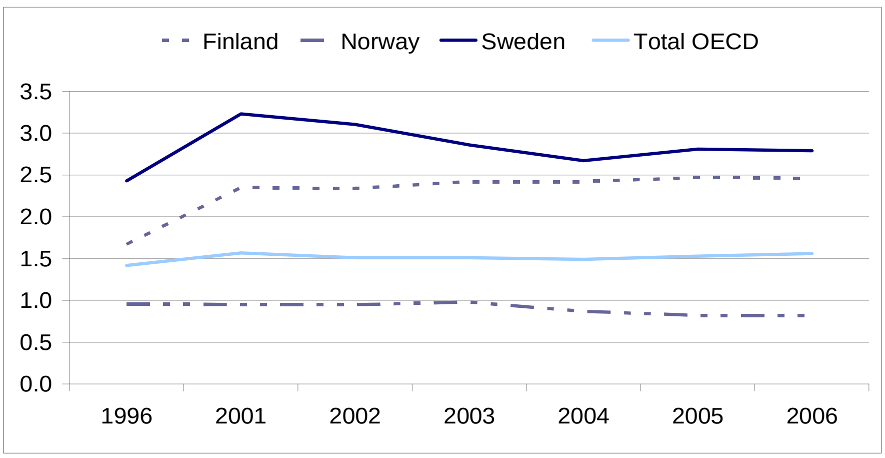


Chart 2. Business expenditure on R&D as a percentage of GDP, 1996-2006



Sources: OECD Science and Innovation, Country Notes, Sweden; OECD Facebook 2009.

CHAPTER 3: LITERATURE REVIEW

This section starts with a brief introduction of the relevant economic theories and then discusses the previous empirical studies on the topic of cash flow - investment sensitivity. Based on the findings of the empirical studies, I discuss them in different subsections (knowledge condition, financial system, firm size, and so forth).

3.1 Theories

Theories on Market Imperfection and financial constraints

The neoclassic economic theories suggest that the capital market is frictionless, the competition is perfect, the information is freely available, and the agents are perfectly rational (Modigliani & Miller, 1958). Under such perfect capital market, firms' investment decisions are not affected by their financial situation and capital structure. The reality shows that the perfect capital market is not always the case. There have been more studies in the recent decades suggesting that the capital market is imperfect. Myers and Majluf (1984) suggest that the asymmetric information between firm and external investors result in investors requiring a risk premium which reflects the average risk of the investment. Due to the extra cost of the risk premium, firms prefer using internal generated funds for investment. The risk premium varies in different forms of external funds. Therefore, if the firm has to raise external funds, it prefers to start with the safest way: debt, hybrid securities such as convertible bonds, and stocks at the last. This is called the "pecking order theory". Jensen and Meckling (1976) argue that the capital structure of a firm can influence its investment decision. For example, a firm with very high leverage may lead to wealth transfer from stockholders to creditors as creditors are paid prior to stockholders. The firm's management that acts on behalf of the stockholders may not invest in profitable projects, which results in the underinvestment problem and low cash flow availability. Jensen (1986) suggests that when free cash flow is larger than profitable investment opportunities, it could cause the firm's management to use the cash to invest in optimizing the firm size than paying dividend to shareholders. Thus, when good investment opportunity comes, the firm appears to be constrained to cash flow.

Situation in R&D Investment

Investment in R&D is very much different from investment in fixed capital in several ways. The extent of information asymmetry is larger for R&D investment than for tangible investment due to limited information disclosure about R&D to reduce competition. Sometimes overprotection could cause underinvestment problems as the research opportunities are not fully exploited. A large part of R&D expenditures is used for paying the salary of research experts. It is hard to hire or fire the researchers because losing them means losing knowledge to competitors. Therefore, R&D expenditures tend to be planned over a long period compared to other investments (Malmberg 2008). Furthermore, it is hard to obtain bank loans for R&D projects as banks usually require collateral for lending. Lastly, in some countries such as the US and Sweden, investment in R&D receives tax benefits. Such tax benefits make internal financing more preferable than raising external funds.

3.2 The FHP – KZ Debate on Financial Constraints and Cash Flow Sensitivity

The debate on the empirical findings of cash flow – investment sensitivity began with the study by Fazzari, Hubbard, and Petersen (1988, denoted as FHP). FHP tested the effect of internal cash flow on firms' capital investment using a sample that consists of three groups of US manufacturing firms categorized by their long-term dividend ratio (a proxy for financial constraints). They find that liquidity has a larger impact on the investment for the low-dividend firms (mostly young start-up firms) than for the high-dividend firms (mostly mature firms). In other words, young firms usually face more financial constraints in comparison to mature firms. FHP's methodology has been applied by a number of studies to determine the relationship between financial constraints and investment decisions. Besides the dividend ratio, they have included more factors such as firm size, debt capacity, and ownership structure that are considered to affect firms' ability to raise funds. Generally, these studies show that firms with larger financial constraints tend to be more sensitive towards internal cash flow (see for example Schaller and Chirinko 1995, Hubbard 1998).

A more recent article written by Kaplan and Zingales (1997, denoted as KZ) challenges the approach of FHP. KZ conducted the study according to both quantitative and qualitative criteria. In contrary to FHP, KZ's results show that the least financially constrained firms appear to be the most sensitive towards internal cash flows. Therefore, they consider the FHP's methodology to be inappropriate in measuring financial constraints. The KZ's argument has been further supported by Cleary (1999) who conducted a study on a much larger sample (1317 firms) and more recent data (1987-1994).

Allayannis (2005) gives one possible explanation of the differences in FHP and KZ's findings. He suggests that the different result obtained by KZ is due to the negative cash flow observations in their sample. When a firm is in a significantly bad shape (having negative cash flows), it tends to minimize its investment schedule, and thus its investment cannot respond to the cash flow, which yields very 'low' cash flow-investment sensitivity.

3.3 Investment and National Financial System

The effect of financial system on investment has been brought out by many researchers. Mulkay, Hall and Mairesse (2001) conduct a comparative study on both fixed capital and R&D investment of a group of US firms and French firms. They obtain similar results as FHP. In addition, they find that the US firms were more sensitive towards internal cash flow than the French firms. They believe that it is due to the different financial market disciplines and investor behaviors - the US investors had smaller share ownerships and were more likely to sell shares than the French investors. Thus the US firms have quicker responsiveness on the cash flow shocks when they were to make investment decisions. The cash flows of the US firms had a better predictability for future profitability than in France.

More evidence has been found by the comparative studies done by Bond, Harhoff, and Reenen (1999) on Belgium, Germany, France and UK. One interesting result that Bond et al observe is when they compare the cash flow – investment sensitivity between Germany and UK. German firms appear to be much less sensitive to internal cash flow than the British firms. In Germany, banks represent a supervisory role to firms. Such relationship mitigates the information-asymmetric problems for both borrowers and lenders. Moreover, large German firms tend to be unquoted (i.e. not listed in the stock market), which strongly prevents firms from hostile takeovers. In addition, the German firms' dividend payout ratio is much lower than the British firms. The 'relationship-oriented' system in Germany makes the German firms less dependent on cash flow compared to the 'market-oriented' system in the UK. Like

Germany, the Japanese financial system is also found to be relationship-oriented. The study conducted by Hoshi, Kashyap, and Scharfstein (1991) shows that the firms belonging to a special network (the 'keiretsu' group) tend to be financially unconstrained compared to the other firms. The 'keiretsu' network is supported by large banks in Japan. Thus the firms in the network have easier access to bank loans.

3.4 Investment and Firm Knowledge Condition

Does knowledge condition of firms make a difference in financing decisions? Himmelberg and Peterson (1994) are among the first authors who try to find a linkage between internal financing and firm R&D. They conduct a study on a sample of 179 small, high-tech US firms. They find a strongly positive and significant relationship between firms' internal cash flow and their R&D expenditure. Applying the same method, Ughetto (2008) analyzes a panel of Italian high-tech firms. She obtains consistent results with Himmelberg and Peterson, i.e. internal cash flow is the large determinant of R&D expenditure in small and medium-sized firms. By contrast, Audretsch and Weigand (2005) categorize the German manufacturing firms into "high-tech" and "low-tech" groups according to the firms' R&D expenditure levels, and they observe that the former group is less financial constrained than the latter. They explain that it is because the "high-tech" group contains a large number of big firms which do not have problems in raising external funds.

3.5 Investment and Firm Size

In most of the previous studies, firm size has been used as a control factor for firms' accessibility to external funds. The common sense says that small firms are usually at an early developmental stage, having high firm-specific risks and little collaterals. All these traits inhibit the firms to obtain external funds. Gertler and Gilchrist (1994) suggest that small firms appear to be more sensitive towards the tightening of monetary policy than large firms. Gilchrist and Himmelberg (1995) find excessive sensitivity for the small firms which neither issue commercial paper nor have bond ratings.

However, contrary evidence can also be found in a number of studies. FHP points out that small firms show smaller cash flow coefficient in their samples. A study done by Kadapakkam, Kumar, and Riddick (1998) on a sample of 6 OECD countries suggests that large firms display higher cash flow – investment sensitivity due to the higher degree of information asymmetry and agency cost in the large firms.

3.6 Investment and Stock Market

Firm investment and the stock market are believed to positively correlate. The common explanation for this relationship is that the marginal product of capital moves in line with the ratio of firm's market value and the replacement value of its capital stock (the book value of firm equity), i.e. "Tobin Q" ratio (see e.g. Tobin, 1969). Thus, the Tobin Q ratio is often used as the indicator for investment opportunity in many empirical studies. There has been criticism on this relationship. Blanchard, Rhee, and Summers (1993) analyze the US economy data from 1900 to 1990. They find that stock market valuation is not a sufficient proxy for predicting investment in comparison to "fundamentals" – the present discounted value of future profits. Nevertheless, when Baker, Stein, and Wurgler (2003) test the non-fundamental factors on a panel of US firms through 1980 until 1999, they find that the stock market has a stronger impact on the investment of "equity-dependent" firms. These firms are usually the young firms with low cash balance and high investment opportunities.

3.7 Other Factors that Influences Investment

Besides the above discussed aspects, there are some other aspects such as firms' ownership scheme, also influence the investment. Audretsch and Weigand (2005) observe financial constraints in the 'small, manager-controlled firms' while no financial constraints for the 'small, owner-controlled firms' in both high and low tech industries. In the comparative studies of Bond et al (1999), they also mention that German firms tend to have more concentrated ownership than the British firms.

Firms' financial and operating situation is also taken into account. Hovakimian (2006) suggests that both bond rating and assets tangibility (measured by dividing the firm's book value of fixed capital over total assets) influence the cash flow - investment sensitivity. Cleary (1999) suggests that a firm with a healthier balance sheet appears to be less financially constrained. In addition, they suggest that firm profitability and sales growth are important factors for measuring the needs of internal cash flow.

The only study that is related to the Swedish market was conducted by Malmberg (2008) on a sample of Swedish pharmaceutical firms from the 1960s to the mid 1990s. He includes one year lag of the cash flow in order to see the effect of previous cash flow on current investment. His result shows that the R&D productivity is significantly influenced by the past cash flow. This suggests that the Swedish firms are benefiting from tax relief in using internal cash flow. Furthermore, it also suggests that the financial system in Sweden may be slowly moving from “relationship-based” towards “market-based” system.

CHAPTER 4: DATA & METHODOLOGY

This chapter starts with introducing the independent and dependent variables used in the regression analysis. Then I will formulate the hypothesis and illustrate the data samples. In the end, I will discuss the panel data methodology and some statistic diagnostic tests applied in the thesis.

4.1 Variables

Independent Variables

Cash Flow. Cash flow is usually defined as profit before allocations and tax, plus depreciation changes, minus tax, and plus after-tax R&D expenditures[1] (see e.g. Hall 1992 and Malmberg 2008). The actual effective tax rate in Sweden was 28% during the period of study. Cash flow of previous year was used in the variable.

Sales. Sales are closely related to profit and thus related to new investment. In the model the sales of previous year were included.

Increase/Decrease in Long-term Debt (ΔDebt). Yearly change in long-term debt represents firms' accessibility to the financial sources other than internal cash flow. Here long-term debt mainly reflects bank loans.

Firm Size (ln Assets). Firm size is used as a proxy for determining level of financial constraints. Here I calculate the natural logarithm of firm's total assets at t-1.

Tobin's Q. Some of the previous studies used Tobin's Q as a measure of firm's future investment opportunity. The Q ratio was calculated by dividing firm's market value at t-1 (taken from company accounts) over firm's book value (total assets minus liabilities) at t-1.

Dependent Variables

Research and Development Investment (R&D). R&D investment was measured by the amount of money that firms spend on R&D every year. It can be found in the firm's income

[1] Here it assumes that R&D is spent every year and therefore it reduces the taxes paid. The fixed assets depreciate over time and hence affect the variation of yearly cash flow and profit (and tax) less. As the low-tech firms barely invest in R&D, the after-tax R&D term is almost zero, and the same cash flow ratio could also be used in the fixed assets equation.

statement under the ‘WC01201’ (R&D expenditure) item in Datastream.

Fixed Capital Investment (Changes in Property, Plants, and Equipment). Fixed capital investment here includes yearly growth in property, plant and equipment (ΔPP&E). The PP&E term in the company’s yearly accounts represents the total amount of machinery and equipment of the company. Therefore, to obtain the growth, I take the difference of year-end and year-beginning PP&E. Acquisitions and disposals are not included in calculating the fixed capital investment for the following reasons: acquisitions occur rarely for the selected firms, while disposals (as suggested by Bond et al (1999) and others) do not seem to affect the robustness of results.

“Normalization” of the Variables

Absolute values of the above mentioned variables may vary quite a lot due to differential firm size. Without any pre-processing of the data, this would lead to excessive significance of large firm samples, while those of small firms would become unimportant.

In order to avoid such undesired variability, many studies suggested to “normalize” the variables, dividing them by a measure that reflects the firm size. I chose to consider the ratios of the above mentioned variables over the firms’ total assets.

Descriptive Statistics

The following table presents the descriptive statistics of the independent variables and the dependent variables.

Table 1. Descriptive Statistics

	R&D	Fixed Capital	Cash Flow	Delta Debt	Sales/Assets	Ln(Assets)	Tobin Q
Mean	0.108021	0.032885	0.085392	0.015457	1.099287	13.47066	1.728402
Median	0.041073	0.002503	0.113337	0	1.076454	13.20226	1.18427
Maximum	1.913701	4.253021	0.669599	0.538067	3.697796	19.60434	10.45762
Minimum	0	-0.795225	-0.448579	-0.696876	-0.018881	6.928538	0.095509
Std. Dev.	0.166705	0.221534	0.152363	0.110867	0.661452	2.337847	1.646459
Observations	603	1346	543	1328	1353	1356	1211

4.2 Hypotheses

On the basis of theories and discussion in previous literature, I formulated the following hypotheses:

H1: Small firm investment in R&D is positively related to internal cash flow.

When firms operate under imperfect market and face the risks of raising external funds, they would mainly be using internal cash flow to finance their R&D activities. This is especially the case for small firms, as small firms are usually at early developing stage, having high firm-specific risk, and little collateral. The reason why I do not have the same assumption for the large firms is that, as literature suggested, large firms tend to use internal cash flow to expand firm size. Therefore, I assume that large firms are constrained to cash flow on fixed capital investment, as given in H2.

H2: Large firm investment in fixed assets is positively related to internal cash flow.

As pointed out by some studies, due to agency problem managers often prefer using cash reserves to expand the firm size as firm size is linked to management bonuses. I assume that large firm investment in fixed capital is sensitive to cash flow.

H3: Firm investment in fixed assets is positively related to the changes in long-term debt.

Unlike the US and UK, the Swedish financial system has been functioning under the bank-based form since the early 20 century (see e.g. Malmberg 2008). Such bank-industry relation provides great responsibility in corporate funding and also higher ownership concentration. At the time of distress, banks are able to increase credit granted and shareholding. Furthermore, as Audretsch and Weigand (2005) suggested, the deregulation and liberalization of the financial sector in the European Union gives more chance for large firms to directly access the capital markets. Thus more funds are also available for the small and medium-sized firms. Therefore, I assume that access to long-term debt should correlate positively with investment in fixed assets and less so with R&D expenditures (because of their higher risk).

H4: Firm investment in R&D and fixed assets is positively related to Tobin's Q for high tech firms and SMEs.

Tobin's Q ratio is thought to be related to firm investment opportunities as it reflects the future expectations of the market. It is considered a particularly good indicator for equity dependent firms, such as small and high tech firms.

H5: Firm investment in R&D and fixed assets is positively related to sales for low tech and large firms.

Some studies also pointed out that Tobin's Q ratio is a less perfect indicator for investment opportunities (see e.g. Kaplan and Zingales 1997 and Hubbard 1998). Therefore, particularly for large and low tech firms, I chose to use the sales-to-assets ratio, which represents the utilization of firms' total assets and thus should act as a fair indicator for measuring the needs of additional investment (see e.g. Audretsch and Weigand 2005).

H6: Relative investment in R&D of high tech firms is negatively related to firm size

Substantial spending on R&D is essential for small technology-oriented firms in order to gain competitive edge. As firms grow, although the absolute value of R&D investment may increase, the ratio of R&D over assets is likely to decrease because more funds are invested in various other operations.

4.3 Data Source

The sample is taken from all the manufacturing firms (340 firms) that are listed on the Stockholm Stock Exchange (OMX) via *Datastream*. Banks, insurance companies, and other service firms were excluded. The firms are selected into the sample if they have either R&D expenditure or fixed capital investment data available in Datastream. In order to capture the effect of a business cycle, I have chosen a ten-year period (1998-2007) for the analysis. The final sample consists of 154 firms listed on the Stockholm Stock Exchange, which can be divided into 12 big industrial categories and 23 sub-industries. **Table 2** shows more details on the different industrial categories:

Table 2. Sample Firm Industrial Categories

Industrial category	Number of Firms
Mining, Construction and Energy	21

Food Producers and Retailers	10
House Hold and Personal Goods	9
Paper and Forestry	7
Industrial Transportations	3
Automobile and Heavy Machines	9
Telecommunication	3
Industrial Engineering	12
Biotechnology and Heath Care	26
Electrical Equipments	18
Computer Software	26
Technology Hardware	10
Total	154

Appendix 1 lists the names of all the firms in the sample.

4.4 Data Sub-samples

In order to capture the effects along different dimensions and test specific hypotheses, I have divided my total sample into different pairs of sub-samples. Both R&D expenditure and fixed capital investment were measured using these sub-samples.

Large firm vs. SMEs. The firms were divided into 'Large' and 'Small & Medium' groups according to the number of employees – firms having over (and incl.) 500 employees were considered large while those with under 500 employees were considered Small & Medium.

High-tech vs. Low-tech. The high-tech and low-tech firms are categorized based on the German ZEW innovation survey, according to the R&D expenditure in percent of sales revenue[2].

Full sample vs. only positive cash flow. To capture the effect of the negative cash flow, I made a new sample which excluded the negative cash flow observations and performed the same tests as in the full sample.

In the late 1990s, due to the speculative activities surrounding the emerging technologies such as internet and e-commerce, the "dot-com bubble" appeared in the stock market worldwide. The stock market bubbles often create high prices in IPO (Initial Public Offering)

[2] Beise and Licht (1996), ZEW innovation survey (Mannheimer Innovationspanel, Zentrum fur Europaische Wirtschaftsforschung)

and cause overvaluation of the stocks. To capture the possible effect of the IT bubble in the Swedish market, I also conducted the analysis on a smaller time frame from 2001 to 2007.

4.5 Panel Data Methodology

When the sample dataset contains both cross-sectional and time-series dimensions, it could be analyzed as either pooled data or panel data. The main difference between these two types is that the former has relatively fewer cross-sections compared to time horizon while the latter has relatively larger cross-sections. For this reason, I chose to apply panel data methodology on my sample with 154 cross-sections and 10-year period. This gives 1540 observations is not taking into account the missing observations.

Baltagi (2005) summarized a number of benefits of using panel data methodology in comparison to single-dimension analysis. Firstly, panel data suggests that individuals, firms, states or countries are heterogeneous. Using only cross-sectional or time-series measurement which does not assume heterogeneity could cause biases in the results. Secondly, panel data method provides more information, more variables and more degree of freedom than single cross-sectional or time-series. Therefore, it faces fewer multicollinearity problems. Lastly, panel data method allows us to measure various effects from the variables and is suitable to apply with advanced econometric models.

4.6 The Dynamic Regression Model and the Autoregressive Disturbed Lag

The following table summarizes the independent variables and dependent variables used in the regression analysis.

Table 3. Summary of Variables

Independent variables of the regression		Dependent variables
$x_1 = \dfrac{cash \cdot flow_{t-1}}{assets_{t-1}}$	$x_4 = \ln(assets_{t-1})$	$y_1 = \dfrac{R\,\&\,D_t}{assets_{t-1}}$
$x_2 = \dfrac{debt_t - debt_{t-1}}{assets_{t-1}}$	$x_5 = Tobins \cdot Q = \dfrac{market \cdot value_{t-1}}{book \cdot value_{t-1}}$	$y_2 = \dfrac{PP\,\&\,E_t - PP\,\&\,E_{t-1}}{assets_{t-1}}$
$x_3 = \dfrac{sales_{t-1}}{assets_{t-1}}$	$x_6 = \dfrac{R\,\&\,D_{t-1}}{assets_{t-1}}$	

In this study I used the dynamic regression model. It is a model that includes a lagged value of a dependent variable or an independent variable (called the autoregressive disturbed Lag, ADL), or both (Brooks 2008). Such model has recently gained popularity in estimating panel data in various fields. In this study, a lagged dependent variable was included on the right hand side of the R&D equation due to two reasons. Including the lagged dependent variable could help to capture the dynamic and long-term effect of the inputs on the dependent variable. Another reason and probably the main reason of including lagged dependent variable was to eliminate the autocorrelation in residuals (see e.g. Hendry and Mizon 1978). More specifically, if there is residual autocorrelation, the lagged dependent variable causes the coefficients for explanatory variables to be biased downward (Keele and Kelly, 2005). The Durbin-Watson test result showed that there was residual autocorrelation in the R&D equation while it did not appear in the fixed assets investment equation. Therefore, the lagged dependent variable was only included in the R&D equation. The regression models are constructed as follows:

$$\frac{R\&D_t}{assets_{t-1}} = c + \beta_1 \frac{cash\_flow_{t-1}}{assets_{t-1}} + \beta_2 \frac{debt_t - debt_{t-1}}{assets_{t-1}} + \beta_3 \frac{sales_{t-1}}{assets_{t-1}} + \beta_4 \ln(assets_{t-1}) + \beta_5 TobinsQ + \beta_6 \frac{R\&D_{t-1}}{assets_{t-1}} + \varepsilon_{it}$$

$$\frac{PP\&E_t - PP\&E_{t-1}}{assets_{t-1}} = c + \beta_1 \frac{cash\_flow_{t-1}}{assets_{t-1}} + \beta_2 \frac{debt_t - debt_{t-1}}{assets_{t-1}} + \beta_3 \frac{sales_{t-1}}{assets_{t-1}} + \beta_4 \ln(assets_{t-1}) + \beta_5 TobinsQ + \varepsilon_{it}$$

Time-fixed Effect

To capture the time effect such as the IT bubble in the late 90s on the estimation, one could apply the time-fixed effect on the regression. The logic behind this method is that by adding a time-varying intercept v_{it} into the regression model, it helps to capture all the variables that affect y_{it} over time but not cross-sectionally. In this case, we included the year dummy variables in the regression.

An alternative to the fixed effects model is the random effects model. The latter model not only includes the additional intercept v_{it} but also includes a random value e_{it}. Literature suggests that when the sample has been randomly selected from the population, the random effect is more appropriate, while the fixed effect is suitable for the sample representing the entire population. In addition, random effects model requires both v_{it} and e_{it} to be uncorrelated with all the independent variables. For these reasons, I chose to consider fixed effects in my regression estimation.

4.7 Regression Diagnostic Tests

Several diagnostic tests were performed in order to check the statistical properties of the regression models. The diagnostic tests results can be found in the second half of **Chapter 5**.

Multicollinearity

In a regression model, it is assumed that the independent variables are not highly correlated with each other; otherwise the problem of multicollinearity occurs. One could determine multicollinearity by looking at the correlation matrix of the independent variables.

Panel Unit Root Test

Unit root test is used to determine whether or not a series is stationary. The stationarity of a series can strongly influence its behavior and properties (Brooks, 2008). The panel-based unit root test is considered more powerful than single series-based unit root test. EViews conducts the following five types of panel unit root tests: the Levin–Lin–Chu (2002), Breitung (2000), Im–Pesaran–Shin (2003), and Fisher-type (Choi 2001) tests assume that all the panels contain a unit root. The Hadri (2000) test has the null hypothesis that all the panels do not contain unit root. Most of the tests assume balanced panel data, while the Im–Pesaran–Shin (2003), and Fisher-type (Choi 2001) tests can also be conducted on unbalanced panel data. In this thesis I use unbalanced panel datasets and therefore I chose to perform the Im-Pesaran-Shin (2003) test for all of the series.

Residual Autocorrelation

The OLS regression assumptions require the residuals not to be correlated with each other. Ignoring residual autocorrelation could cause wrong estimation of standard error and inefficient estimation of beta coefficient (Brooks 2008). EViews has not provided many tests for determining the residual autocorrelation in panel estimation. The Durbin-Watson ratio shown under the regression results is one type of indicator for autocorrelation.

As the lagged dependent variable is included in the regression, the Durbin-Watson test becomes invalid. Instead, one has to rely on the Breusch-Godfrey test or the Durbin h-statistic for determining the autocorrelation in the panel estimation.

CHAPTER 5: RESULTS

The main results of the regressions are provided in **Table 4** (for R&D investment) and **Table 5** (for fixed capital investment), where the data from years 1998-2007 is included. In the following sections I discuss the results in relation to the hypotheses and evaluate their robustness. The detailed regression results are shown in **Appendix 2.**

5.1 Effects of the Cash Flow

Unlike expected by hypothesis H1, the correlation between internal cash flow and R&D expenditure is positive, but insignificant for SMEs ($\beta_1 = 0.021$, $p = 0.42$) as well as when considering the full sample ($\beta_1 = 0.019$, $p = 0.24$). Interestingly, for large ($\beta_1 = -0.041$, $p < 0.001$) and low tech ($\beta_1 = -0.024$, $p = 0.001$) firms there is even a significant negative relation, suggesting that relatively higher internal cash flow leads to relatively lower R&D investment for these firms. This could mean that with increasing cash flow these firms do not increase their R&D to a similar extent.

In accordance with hypothesis H2 (and consistent with the study of Hubbard 1998), I observed that for large firms their internal cash flow is strongly positively related to fixed capital investment ($\beta_1 = 0.125$, $p = 0.005$). The same effect was observed when considering the full sample ($\beta_1 = 0.037$, $p = 0.003$), suggesting that for Swedish companies in my sample, internal cash flow is generally a stronger predictor of investment in fixed capital rather than in R&D.

5.2 Effects of the Ability to Raise Debt

As expected by hypothesis H3, I found that firm's ability to raise debt has positive and significant effect on the fixed capital investment, which was robust and apparent both when considering the full sample (β_2 = 0.176, p<0.001) and all different subgroups (low vs. high tech and large vs. SME), although it could be noted that coefficients β_2 were the highest for large and low tech groups. There was however, no significant relation between the debt variable and the R&D investment, suggesting that firms do not use their increased debt capabilities in boosting their relative R&D expenditure but rather invest in (more reliable) fixed assets.

5.3 Effects of the Investment Opportunities

In accordance with hypothesis H4, Tobin's Q measure of investment opportunity had positive relations with R&D investment (β_5 = 0.0048, p = 0.001) and fixed capital investment (β_5 = 0.0025, p = 0.008) only for high tech firms, but not for low tech ones. Similar to high tech firms, for SMEs investment opportunity (Tobin's Q) had a significant effect on both fixed capital investment (β_5 = 0.0020, p = 0.039) and R&D expenditure (β_5 = 0.0046, p = 0.022, suggesting that Tobin's Q investment opportunity measure is indeed the most important predictor of both R&D and fixed assets investment for small high tech companies (which are likely at their early stages of operation).

Differently from what was expected in hypothesis H5, sales-to-assets ratio did not show any positive significant relations either to R&D or to fixed assets investment for low tech or large firms. For high tech firms there was even a negative correlation with R&D investment (β_3 = –0.018, p = 0.035), suggesting that while these firms may initially invest a lot into R&D, upon increase in sales they reduce their relative R&D investment.

5.4 Effects of the Firm Size

Finally, I found that in accordance with hypothesis H6 firm size was an important factor correlating negatively with firms' R&D only for high tech firms (β_4 = –0.0056, p = 0.003), but not for low tech ones, perhaps because low tech firms do not have initial large investment in R&D (when they are still small). No correlations were observed between firm size and investment in the fixed assets.

Table 4: Summary of Regression Results on R&D investment (with both positive and negative cash flow)

Summary results of dynamic panel regression, 1998-2007					
Independent Variables for prodicting financial constraints	Dependent Variable: R&D investment ratio				
	Estimated coefficient (p-value)				
	Full Sample	High-tech firms	Low-tech firms	Large firms	SMEs
Cash flow ratio	0.019482 (0.2397)	0.029919 (0.121100)	-0.023802 (0.001300)**	-0.040954 (0.000700)***	0.020818 (0.420000)
Changes in long-term Debt ratio	0.004436 (0.731200)	0.00701 (0.659000)	0.003228 (0.122700)	0.005554 (0.146400)	0.004936 (0.825300)
Sales ratio	-0.013839 (0.048900)*	-0.018048 (0.034800)*	0.000833 (0.534600)	0.000232 (0.898500)	-0.015321 (0.285900)
Firm size effect	-0.004757 (0.001600)**	-0.005599 (0.002700)**	-0.000243 (0.355000)	0.0000751 (0.860900)	-0.006013 (0.365700)
Investment opportunity effect	0.005136 (0.000100)***	0.004786 (0.001400)**	0.0000495 (0.927100)	0.002586 (0.001100)**	0.004578 (0.021500)*
R&D lag-1	0.637813 (0.000000)***	0.617574 (0.000000)***	1.101870 (0.000000)***	0.950681 (0.000000)***	0.650061 (0.000000)***
R-squared	0.681334	0.653420	0.934027	0.930516	0.577246
Adjusted R-squared	0.677213	0.647860	0.929079	0.928772	0.564873
F-statistic	165.344700	117.519500	188.770200	533.441300	46.652590
Prob(F-statistic)	0.000000	0.000000	0.000000	0.000000	0.000000
Durbin-Watson stat	1.901767	1.878869	2.053385	1.964221	2.027047

* Significant at 0.05 level

** Significant at 0.01 level

*** Significant at 0.001 level

Table 5: Summary of Regression Results on Fixed Capital Investment (with both positive and negative cash flow)

Summary results of dynamic panel regression, 1998-2007					
Independent Variables for prodicting financial constraints	Dependent Variable: Fixed Capital Investment ratio				
	Estimated coefficient (p-value)				
	Full Sample	High-tech firms	Low-tech firms	Large firms	SMEs
Cash flow ratio	0.036772 (0.003000)**	0.030169 (0.009500)**	0.036455 (0.517700)	0.124904 (0.004500)**	0.030811 (0.012200)*
Changes in long-term Debt ratio	0.176303 (0.000000)***	0.141059 (0.000000)***	0.309950 (0.000000)***	0.263146 (0.000000)***	0.126348 (0.000000)***
Sales ratio	-0.002948 (0.558400)	-0.000619 (0.899400)	-0.019895 (0.534600)	-0.002225 (0.767500)	-0.009912 (0.117100)
Firm size effect	0.001352 (0.212100)	0.001314 (0.225700)	-0.000243 (0.089400)	0.000101 (0.953100)	0.002435 (0.444600)
Investment opportunity effect	0.002348 (0.020900)**	0.002516 (0.007700)**	-0.000410 (0.917900)	-0.000636 (0.842900)	0.002030 (0.038600)*
R-squared	0.396933	0.357035	0.748454	0.536353	0.401154
Adjusted R-squared	0.391124	0.349288	0.735073	0.528103	0.388021
F-statistic	68.320310	46.089460	55.937680	65.012890	30.546450
Prob(F-statistic)	0.000000	0.000000	0.000000	0.000000	0.000000
Durbin-Watson stat	1.802592	1.814034	2.057580	1.848454	1.789731

* Significant at 0.05 level

** Significant at 0.01 level

*** Significant at 0.001 level

5.5 Regressions Including Positive Cash flow only

Following suggestions in certain articles (e.g. Allayannis 2005), I investigated how our results could be affected by exclusion of firms' records containing negative cash flows (see **Appendix 3** and **Appendix 4**). It is evident that the relation between cash flow and R&D (which has not been significant in the full sample) did not change, whereas many other effects that appeared as significant in the main sample were no longer such. It is likely that the results were distorted (and significances disappeared) due to reduction of many data points. In particular, for SMEs the number of records decreased sharply (from 212 to 72) as the negative cash flow was taken away.

5.6 Diagnostic Tests and Robustness of Results

Correlation Matrix

The following table shows the correlations among every independent variable. The results indicate no strong correlation (-0.8 < correlation coefficient < 0.8) between the independent variables, which means that no multicollinearity is present.

Table 6: Correlation Matrix

	Cash flow / Assets	Delta Debt / Assets	Sales / Assets	Ln (Assets)	Tobin's Q
Cash flow/Assets	1.000000				
Delta Debt/Assets	0.013783	1.000000			
Sales/Assets	0.353701	0.049804	1.000000		
Ln(Assets)	0.324197	0.010132	0.187070	1.000000	
Tobin's Q	0.066999	-0.004447	-0.252770	-0.323667	1.000000

As sales are the main way of generating internal cash flow, the sales ratio has the strongest and positive correlation with cash flow ratio. Cash flow is also positively correlated with firm size. However, sales ratio is negatively correlated with the Tobin's Q ratio. This may be reasonable as the small and high-tech firms which have great investment opportunities are currently generating little or negative sales. A similar reasoning could be applied for the negative correlation between investment opportunity and firm size.

Unit Root Test

The Im-Pesaran-Shin (2003) test was performed on all the independent and dependent variables. The null hypothesis of the test assumes that the series contain a unit root. In summary, the null hypothesis was rejected for all of the series, which means that no unit root process was found. The details of the test results can be found in **Appendix 5**.

Residual Autocorrelation

From the original test results of the Durbin-Watson test, one could observe that there was a residual autocorrelation in the R&D equation. For example, the DW ratio was 0.47 for the full sample test. Therefore, I included the lagged dependent variable in order to correct the autocorrelation as suggested by many studies. For the full sample, for example, the DW ratio became 1.91, while this did not cause a substantial effect on the significance of the beta coefficient. However, literature suggests that DW is not an appropriate indicator of autocorrelation when lagged dependent variable is included. EViews has not provided any other tests for residual autocorrelation on panel data estimation due to the complexity of the dataset. Therefore, one could not verify this point conclusively.

Residual normality test was performed for both R&D and fixed capital equations. It showed that the residuals of the former equation were very close to normal distribution while those of the latter one were not. The residual distribution can be found in **Appendix 6**.

5.7 Robustness of the Results

I included the year fixed dummy variables in the regression estimation in order to capture the effect of different time period. The results indicated no significant change in the coefficients, compared to previous results without year fix dummies. For example, the p-value of cash flow coefficient in the R&D equation changed from 0.23 to 0.65, remaining insignificant (See **Appendix 7**). The result of regression for the period of 2001-2007 was consistent with the full-year estimation with period fixed dummies. This suggests that the IT bubble, which happened in the late 1990s, did not have a significant effect on the firms' investment behavior investigated in this study. The tested results were robust during the period of investigation.

Several coefficient covariance methods such as period SUR were applied in the estimation. However, they did not appear to change the tested results to a substantial extent either. The results still stay robust.

CHAPTER 6: DISCUSSION

In this study I showed that firms' investment in R&D and fixed assets is constrained by many different factors that are dependent on firm's size and its technological orientation (high or low tech). Most of the hypotheses raised in chapter 3 were confirmed, except that R&D investment was not found to be sensitive to internal cash flow and sales. Overall R&D investment seemed to be most affected by the market (Tobin's Q investment opportunity ratio), whereas fixed assets investment was most influenced by the ability to raise debt and the cash flow.

As expected, the ratio between long term debt change and assets had a consistent positive correlation with fixed capital investment, but not with R&D. It is very consistent with the view that debt financing is much more available for low risk projects than high risk R&D activities. On the other hand, there was generally no relation between the cash flow ratio and the R&D investment. This result is similar to the result of German firms in the comparative study conducted by Bond et al (2003) on German and British firms. Although it was believed that due to globalization Sweden started to switch from "bank-based" system to a system that captures more market effects and engages more in international transactions, my result provides evidence that Swedish manufacturing firms are still operating in the "bank-based" financial system, and having close relationship with financial institutions and relatively easier access to debt financing, just like the German firms.

The second important point is that the cash flow ratio had a negative effect on R&D investment for both low-tech and large firms. Due to the characteristics of low-tech firms, the firms do not invest much or not at all in R&D, and thus the result simply shows that firms' R&D expenditure ratio is relatively decreasing as their cash flow ratio is increasing. For large firms, it might be also due to the agency problem that firm's management spends their free cash flow on increasing firm size instead of R&D, as suggested by Jensen's free cash flow hypothesis (1986), and supported by strong relation between cash flow and fixed assets investment that I observed in my results for large firms. On the other hand, there had not been enough evidences showing that the high-tech and SMEs are financially constrained by internal cash flow. This result varies from Malmberg's (2008) findings on the Swedish pharmaceutical firms during the 1960s and mid 1990s. The differences could be due to the high risks engaged in the pharmaceutical industry. The other types of high-tech industries such as telecommunication have much less uncertainty involved in their projects.

Investment opportunity effect coming from Tobin's Q ratio had a positive impact on firms' R&D expenditure, particularly for high tech firms and SMEs. It means that firm's investment in R&D is increasing with the increase of the firms' market value. In line with the conclusion of Baker, Stein, and Wurgler (2003), stock market valuation has a crucial effect on investment for equity dependent firms. It is important to note here that despite my finding that stock market plays an important role the results did not qualitatively change when the early years of IT bubble (1998-2000) were excluded from the regression. This could be due to multiple reasons such as the small number of companies in our sample that were affected by the bubble at that time (some IT companies in our sample are young and only have records in the later years) or that cross sectional differences among companies (on which my results are strongly dependent) were only amplified but not qualitatively changed.

Lastly, firm size generally tends to be negatively related to its investment in R&D. With increasing size, firms may achieve higher efficiency, thus can invest relatively more money (relative to total assets) into other operations, which is expected and reasonable. Consistent with this point, it is worth mentioning that some important differences between my results and those of other studies could have occurred because in this study I applied not the raw variables, but their ratios over assets in the correlations. As a result, sometimes when the absolute value of, for example, cash flow was increasing, its ratio over assets might still be decreasing, and thus we could often get negative correlation coefficients.

CHAPTER 7: CONCLUSION

This thesis analyzes the factors that influence firms' investment in both R&D and fixed capital. Applying a similar methodology as used in the previous literature on a panel of Swedish firms, I aimed to see how much the study could be generalized on the Swedish market and whether any different results could be captured. The study was conducted on the period from 1998 to 2007. The most important finding is that in the Swedish market cash flow does not seem to be an important determinant of R&D investment. It was rather the Tobin's Q investment opportunity measure correlates well with R&D investment and to a smaller extent with the fixed assets investment. In addition, the ability of raising new debt was found to play an important role for the firms' investment in fixed capital. It suggests that despite the great effect of globalization, Sweden's national financial system still holds the "bank-based" characteristics. It points out that when we analyze the national system of innovation and the R&D expenditure, we should keep in mind the different behaviors among the countries due to specific market characteristics.

In addition to the fact that R&D and fixed asset investment are affected by different factors, (such as stock market for the former and debt financing for the latter), I observed that these effects differed when I considered large and low tech vs. small and high tech firms. Tobin's Q was an important determinant for R&D investment in equity dependent firms (i.e. small and high tech) whereas cash flow was found to influence fixed assets investment in large firms. It is notable that only for high tech firms and SMEs Tobin's Q also correlated with fixed assets investment. This means that for these firms stock market is the most essential indicator of their investment activity. Large firms were found to have a larger diversity of factors influencing their investment activity, suggesting that none of them is probably as critical as stock market indications for SMEs.

Future research could consider additional more complex factors compared to those present in this study. For example, one could consider the cross-border investments done by the Swedish firms, as nowadays many Swedish firms actively engage in international collaboration of R&D activities.

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APPENDIX

Appendix 1: The List of the Sample Firms.

ACANDO 'B'	INTOI
ACCELERATOR NORDIC 'B'	JEEVES INFO.SYSTEMS
ACTIVE BIOTECH	KABE HUSVAGNAR 'B'
ADDVISE	KARO BIO
AEROCRINE 'B'	KNOW IT
ALFA LAVAL	LAGERCRANTZ 'B'
ANOTO GROUP	LBI INTERNATIONAL
ARCAM 'B'	LINDAB INTERNATIONAL
ARTIMPLANT	LUNDBERGFORETAGEN 'B'
ASPIRO	MALMBERGS ELEKTRISKA
ASSA ABLOY 'B'	MEDA 'A'
ATLAS COPCO 'A'	MEDIVIR 'B'
AUDIODEV 'B'	MEGACON
AXIS	MEKONOMEN
B&B TOOLS 'B'	MICRO HOLDING
BALLINGSLOV INTL.	MICRONIC LASER SYS.
BEIJER ALMA 'B'	MOBYSON
BEIJER ELECTRONICS	MODUL 1 DATA
BERGS TIMBER 'B'	MULTIQ INTERNATIONAL
BILIA 'A'	MUNTERS
BILLERUD	NCC 'B'
BIOGAIA 'B'	NEDERMAN HOLDING
BIOINVENT INTL.	NET INSIGHT 'B'
BIOLIN	NETONNET
BIOPHAUSIA 'A'	NETREVELATION
BIOSENSOR APPS.SWEDEN 'A'	NIBE INDUSTRIER 'B'
BIOTAGE	NOLATO 'B'
BIOVITRUM	NOVOTEK 'B'
BOLIDEN	OBDUCAT 'B'
BONG LJUNGDAHL	OEM INTERNATIONAL 'B'
BRIO 'B'	OPCON
C2SAT 'B'	ORC SOFTWARE
CAPERIO HOLDING	OREXO
CARDO	PARTNERTECH
CAROZZI	PEAB 'B'
CATECH 'B'	PRECISE BIOMETRICS
CLAS OHLSON 'B'	PRICER 'B'
CONCORDIA MARITIME 'B'	PROACT IT GROUP
CONPHARM 'B'	PROBI
CONSILIUM 'B'	PROFILGRUPPEN 'B'
CONTEXTVISION	Q-MED
CTT SYSTEMS	RASTA GROUP
CYBERCOM GROUP EUROPE	RAYSEARCH LABORATORIES
DIAMYD MEDICAL 'B'	REDERI AB TNSAT.'B'
DIGITAL VISION	RNB RETAIL AND BRANDS
DUNI	RORVIK TIMBER
DUROC 'B'	ROTTNEROS

EFFNET HOLDING	SAAB 'B'
ELECTROLUX 'B'	SANDVIK
ELEKTA 'B'	SCANIA 'B'
ELEKTRONIKGRUPPEN BK 'B'	SCRIBONA 'B'
ELOS 'B'	SECO TOOLS 'B'
ENEA	SECTRA 'B'
ERICSSON 'B'	SENSYS TRAFFIC
EUROPEAN INST.OF SCI.'B'	SINTERCAST
FAGERHULT	SKANSKA 'B'
FEELGOOD SVENSKA	SKF 'B'
FENIX OUTDOOR	SMARTEQ 'B'
FINGERPRINT CARDS 'B'	SOFTRONIC 'B'
G & L BEIJER	SRAB SHIPPING 'B'
GETINGE	SSAB 'A'
GETUPDATED INET.MKTG.	STILLE
GEVEKO 'B'	STUDSVIK
HALDEX	SVEDBERGS 'B'
HAMMAR INVEST 'B'	TAURUS ENERGY 'B'
HENNES & MAURITZ 'B'	TELE2 'B'
HEXAGON 'B'	TELIASONERA
HIFAB GROUP	TELIGENT
HIQ INTERNATIONAL	TRETTI
HOGANAS 'B'	TRICORONA
HOLMEN 'B'	VBG GROUP
HUMAN CARE H C	VENUE RETAIL GROUP 'B'
HUSQVARNA 'B'	VITEC SOFTWARE GROUP 'B'
IBS 'B'	VITROLIFE
INDL.& FINL.SYS.'B'	VOLVO 'B'
INDUTRADE	WEST SIBERIAN RES.SDB
INTL.GOLD EXP.IGE	XANO INDUSTRI 'B'

Appendix 2: Regression Results

Full Sample

Dependent Variable: Fixed Investment				
Method: Panel Least Squares				
Date: 05/20/09 Time: 19:45				
Sample: 1998 2007				
Cross-sections included: 86				
Total panel (unbalanced) observations: 525				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.023230	0.017288	-1.343723	0.179600
cash flow	0.036772	0.012320	2.984821	0.003000
delta debt	0.176303	0.009896	17.815910	0.000000
sales	-0.002948	0.005033	-0.585669	0.558400
ln(assets)	0.001352	0.001082	1.249340	0.212100
tobin q	0.002348	0.001014	2.316378	0.020900
R-squared	0.396933	Mean dependent var		0.007247
Adjusted R-square	0.391124	S.D. dependent var		0.067785
S.E. of regression	0.052893	Akaike info criterion		-3.029721
Sum squared resid	1.452001	Schwarz criterion		-2.980997
Log likelihood	801.301900	F-statistic		68.320310
Durbin-Watson sta	1.802592	Prob(F-statistic)		0.000000

Dependent Variable: R&D				
Method: Panel Least Squares				
Date: 05/22/09 Time: 00:07				
Sample (adjusted): 1999 2007				
Cross-sections included: 83				
Total panel (unbalanced) observations: 471				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.098197	0.025064	3.917792	0.000100
cash flow	0.019482	0.016548	1.177336	0.239700
delta debt	0.004436	0.012906	0.343697	0.731200
sales	-0.013839	0.007008	-1.974629	0.048900
ln(assets)	-0.004757	0.001501	-3.168876	0.001600
tobin q	0.005136	0.001305	3.937153	0.000100
R&D - lag	0.637813	0.027469	23.219080	0.000000
R-squared	0.681334	Mean dependent var		0.093069
Adjusted R-square	0.677213	S.D. dependent var		0.116723
S.E. of regression	0.066315	Akaike info criterion		-2.574039
Sum squared resid	2.040547	Schwarz criterion		-2.512290
Log likelihood	613.186200	F-statistic		165.344700
Durbin-Watson sta	1.901767	Prob(F-statistic)		0.000000

High Tech

Dependent Variable: Fixed Investment				
Method: Panel Least Squares				
Date: 05/20/09 Time: 19:51				
Sample: 1998 2007				
Cross-sections included: 69				
Total panel (unbalanced) observations: 421				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.025954	0.017310	-1.499345	0.134500
cash flow	0.030169	0.011572	2.607094	0.009500
delta debt	0.141059	0.009765	14.445630	0.000000
sales	-0.000619	0.004892	-0.126495	0.899400
ln(assets)	0.001314	0.001083	1.213305	0.225700
tobin q	0.002516	0.000939	2.678603	0.007700
R-squared	0.357035	Mean dependent var		0.004312
Adjusted R-square	0.349288	S.D. dependent var		0.058445
S.E. of regression	0.047146	Akaike info criterion		-3.256989
Sum squared resid	0.922437	Schwarz criterion		-3.199374
Log likelihood	691.596200	F-statistic		46.089460
Durbin-Watson sta	1.814034	Prob(F-statistic)		0.000000

Dependent Variable: R&D				
Method: Panel Least Squares				
Date: 05/22/09 Time: 17:17				
Sample (adjusted): 1999 2007				
Cross-sections included: 66				
Total panel (unbalanced) observations: 381				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.118939	0.031294	3.800633	0.000200
cash flow	0.029919	0.019259	1.553500	0.121100
delta debt	0.007010	0.015869	0.441709	0.659000
sales	-0.018048	0.008520	-2.118362	0.034800
ln(assets)	-0.005599	0.001855	-3.017804	0.002700
tobin q	0.004786	0.001487	3.218193	0.001400
R&D - lag	0.617574	0.031535	19.583960	0.000000
R-squared	0.653420	Mean dependent var		0.109806
Adjusted R-square	0.647860	S.D. dependent var		0.123245
S.E. of regression	0.073135	Akaike info criterion		-2.374811
Sum squared resid	2.000438	Schwarz criterion		-2.302371
Log likelihood	459.401400	F-statistic		117.519500
Durbin-Watson sta	1.878869	Prob(F-statistic)		0.000000

Low Tech

Dependent Variable: Fixed Investment				
Method: Panel Least Squares				
Date: 05/20/09 Time: 20:03				
Sample: 1998 2007				
Cross-sections included: 17				
Total panel (unbalanced) observations: 100				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.006123	0.034871	-0.175594	0.861000
cash flow	0.036455	0.056138	0.649385	0.517700
delta debt	0.309950	0.019669	15.758010	0.000000
sales	-0.019895	0.011593	-1.716054	0.089400
ln(assets)	0.001932	0.002154	0.896963	0.372000
tobin q	-0.000410	0.003969	-0.103324	0.917900
R-squared	0.748454	Mean dependent var		0.017849
Adjusted R-square	0.735073	S.D. dependent var		0.082029
S.E. of regression	0.042221	Akaike info criterion		-3.433662
Sum squared resid	0.167568	Schwarz criterion		-3.277352
Log likelihood	177.683100	F-statistic		55.937680
Durbin-Watson sta	2.057580	Prob(F-statistic)		0.000000

Dependent Variable: R&D				
Method: Panel Least Squares				
Date: 05/22/09 Time: 18:52				
Sample (adjusted): 1999 2007				
Cross-sections included: 17				
Total panel (unbalanced) observations: 87				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.004601	0.004625	0.994809	0.322800
cash flow	-0.023802	0.007153	-3.327471	0.001300
delta debt	0.003228	0.002069	1.559905	0.122700
sales	0.000833	0.001336	0.623770	0.534600
ln(assets)	-0.000243	0.000261	-0.930299	0.355000
tobin q	0.000050	0.000540	0.091805	0.927100
R&D - lag	1.101870	0.036251	30.395220	0.000000
R-squared	0.934027	Mean dependent var		0.018049
Adjusted R-square	0.929079	S.D. dependent var		0.016669
S.E. of regression	0.004439	Akaike info criterion		-7.919717
Sum squared resid	0.001576	Schwarz criterion		-7.721311
Log likelihood	351.507700	F-statistic		188.770200
Durbin-Watson sta	2.053385	Prob(F-statistic)		0.000000

Large Firm

Dependent Variable: Fixed Investment				
Method: Panel Least Squares				
Date: 05/20/09 Time: 20:34				
Sample: 1998 2007				
Cross-sections included: 48				
Total panel (unbalanced) observations: 287				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.012173	0.033226	-0.366366	0.714400
cash flow	0.124904	0.043664	2.860606	0.004500
delta debt	0.263146	0.015680	16.782380	0.000000
sales	-0.002225	0.007520	-0.295869	0.767500
ln(assets)	0.000101	0.001716	0.058851	0.953100
tobin q	-0.000636	0.003205	-0.198318	0.842900
R-squared	0.536353	Mean dependent var		0.012674
Adjusted R-square	0.528103	S.D. dependent var		0.065728
S.E. of regression	0.045152	Akaike info criterion		-3.336892
Sum squared resid	0.572869	Schwarz criterion		-3.260387
Log likelihood	484.844000	F-statistic		65.012890
Durbin-Watson sta	1.848454	Prob(F-statistic)		0.000000

Dependent Variable: R&D				
Method: Panel Least Squares				
Date: 05/22/09 Time: 19:03				
Sample (adjusted): 1999 2007				
Cross-sections included: 43				
Total panel (unbalanced) observations: 246				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.001743	0.008298	0.210024	0.833800
cash flow	-0.040954	0.011929	-3.433168	0.000700
delta debt	0.005554	0.003812	1.457147	0.146400
sales	0.000232	0.001818	0.127738	0.898500
ln(assets)	0.000075	0.000428	0.175394	0.860900
tobin q	0.002586	0.000780	3.316021	0.001100
R&D - lag	0.950681	0.019338	49.160080	0.000000
R-squared	0.930516	Mean dependent var		0.036130
Adjusted R-square	0.928772	S.D. dependent var		0.037380
S.E. of regression	0.009976	Akaike info criterion		-6.349209
Sum squared resid	0.023786	Schwarz criterion		-6.249464
Log likelihood	787.952800	F-statistic		533.441300
Durbin-Watson sta	1.964221	Prob(F-statistic)		0.000000

Small Firms

Dependent Variable: Fixed Investment				
Method: Panel Least Squares				
Date: 05/20/09 Time: 20:39				
Sample: 1998 2007				
Cross-sections included: 43				
Total panel (unbalanced) observations: 234				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.030703	0.041212	-0.745005	0.457000
cash flow	0.030811	0.012201	2.525396	0.012200
delta debt	0.126348	0.010802	11.696530	0.000000
sales	-0.009912	0.006301	-1.572988	0.117100
ln(assets)	0.002435	0.003180	0.765848	0.444600
tobin q	0.002030	0.000976	2.080498	0.038600
R-squared	0.401154	Mean dependent var		0.001949
Adjusted R-square	0.388021	S.D. dependent var		0.060846
S.E. of regression	0.047599	Akaike info criterion		-3.226695
Sum squared resid	0.516576	Schwarz criterion		-3.138097
Log likelihood	383.523400	F-statistic		30.546450
Durbin-Watson sta	1.789731	Prob(F-statistic)		0.000000

Dependent Variable: R&D				
Method: Panel Least Squares				
Date: 05/22/09 Time: 19:13				
Sample (adjusted): 1999 2007				
Cross-sections included: 41				
Total panel (unbalanced) observations: 212				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.116176	0.086072	1.349754	0.178600
cash flow	0.020818	0.025766	0.807985	0.420000
delta debt	0.004936	0.022327	0.221069	0.825300
sales	-0.015321	0.014320	-1.069852	0.285900
ln(assets)	-0.006013	0.006632	-0.906649	0.365700
tobin q	0.004578	0.001976	2.316963	0.021500
R&D - lag	0.650061	0.044087	14.744820	0.000000
R-squared	0.577246	Mean dependent var		0.155484
Adjusted R-square	0.564873	S.D. dependent var		0.142577
S.E. of regression	0.094050	Akaike info criterion		-1.857524
Sum squared resid	1.813298	Schwarz criterion		-1.746693
Log likelihood	203.897500	F-statistic		46.652590
Durbin-Watson sta	2.027047	Prob(F-statistic)		0.000000

Appendix 3: Summary of Regression Results on R&D investment with positive cash flow only

Summary results of dynamic panel regression, 1998-2007					
Independent Variables for predicting financial constraints	Dependent Variable: R&D investment ratio				
	Estimated coefficient (p-value)				
	Full Sample	High-tech firms	Low-tech firms	Large firms	SMEs
Cash flow ratio	-0.03563 (0.112200)	-0.032763 (0.241500)	0.001418 (0.863800)	-0.007091 (0.744600)	-0.107867 (0.066500)
Changes in long-term Debt ratio	0.019149 (0.000300)**	0.023833 (0.000400)**	0.001069 (0.468000)	0.017296 (0.003500)**	0.018916 (0.142800)
Sales ratio	0.000656 (0.849600)	0.000201 (0.965300)	0.001348 (0.189200)	-0.004245 (0.159500)	-0.001652 (0.895400)
Firm size effect	-0.000626 (0.383700)	-0.00082 (0.395700)	0.000204 (0.338100)	-0.000618 (0.386000)	-0.004056 (0.502400)
Investment opportunity effect	0.000885 (0.456300)	0.000979 (0.502600)	0.000518 (0.216800)	0.002831 (0.024100)**	-0.000288 (0.923800)
R&D lag -1	0.905158 (0.000000)***	0.894234 (0.000000)***	0.933387 (0.000000)***	0.939240 (0.000000)***	0.986877 (0.000000)***
R-squared	0.901165	0.890784	0.906401	0.877296	0.871695
Adjusted R-squared	0.899195	0.887922	0.897762	0.874010	0.860205
F-statistic	457.415400	311.292200	104.909200	266.923000	75.865790
Prob(F-statistic)	0.000000	0.000000	0.000000	0.000000	0.000000
Durbin-Watson stat	2.033024	1.974910	2.154985	2.044589	1.850004

* Significant at 0.05 level

** Significant at 0.01 level

*** Significant at 0.001 level

Appendix 4: Summary of Regression Results on Fixed Capital Investment with positive cash flow only

Summary results of dynamic panel regression, 1998-2007					
Independent Variables for prodicting financial constraints	Dependent Variable: Fixed Capital Investment ratio				
	Estimated coefficient (p-value)				
	Full Sample	High-tech firms	Low-tech firms	Large firms	SMEs
Cash flow ratio	0.027126 (0.314100)	0.028623 (0.271700)	0.114208 (0.284800)	0.104188 (0.068300)	0.028745 (0.165000)
Changes in long-term Debt ratio	0.1817 (0.000000)**	0.175294 (0.000000)**	0.312717 (0.000000)**	0.277838 (0.000000)**	0.163724 (0.000000)**
Sales ratio	-0.000346 (0.949300)	0.003485 (0.534200)	-0.024839 (0.081800)	-0.004124 (0.632100)	-0.005212 (0.358100)
Firm size effect	0.000729 (0.514500)	0.001373 (0.241200)	0.003148 (0.253800)	-0.000654 (0.741900)	0.001977 (0.515500)
Investment opportunity effect	0.002832 (0.060500)	0.002824 (0.059500)	0.000406 (0.929900)	-0.000376 (0.918300)	0.000708 (0.541300)
R-squared	0.428842	0.501412	0.722201	0.493005	0.794775
Adjusted R-squared	0.421685	0.493239	0.706236	0.483886	0.785530
F-statistic	59.916220	61.345610	45.235270	54.065770	85.973760
Prob(F-statistic)	0.000000	0.000000	0.000000	0.000000	0.000000
Durbin-Watson stat	1.637211	1.607844	1.731222	1.710830	1.535414

* Significant at 0.05 level

** Significant at 0.01 level

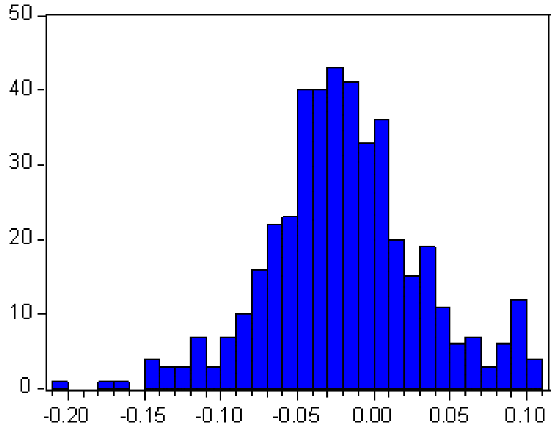
*** Significant at 0.001 level

Appendix 5: Panel Unit Root Test

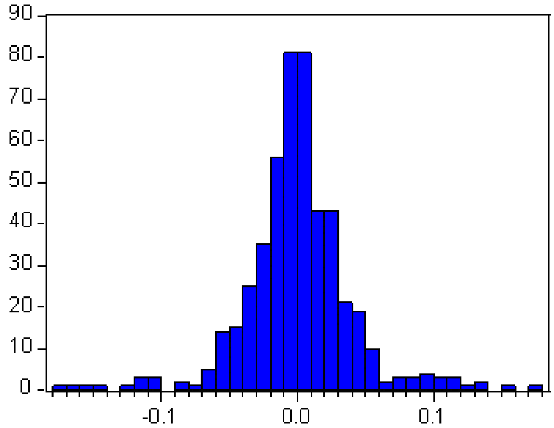
Null Hypothesis: Unit root (individual unit root process)
Sample: 1998 2007
Exogenous variables: Individual effects, individual linear trends

	Cash Flow		Delta Debt		Sales/Assets		Ln(Assets)		Tobin Q		R&D		Fixed Capital	
Total number of observations:	390		1077		1022		1024		884		370		1016	
Cross-sections included:	59		135		142		142		133		61		141	
Method	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.	Statistic	Prob.
Im, Pesaran and Shin W-stat	-3.5933	0.0002	-4.1E+14	0.0000	-5.6686	0.0000	-4.2455	0.0000	-4.7003	0.0000	-4.6792	0.0000	-8.2532	0.0000
Im, Pesaran and Shin t-bar	-3.6002		-8.8E+13		-3.6511		-3.3164		-3.5234		-4.0383		-4.2766	
T-bar critical values : 1% level	-4.0300		-3.3680		-3.3680		-3.3680		-3.6840		-4.0132		-3.3680	
5% level	-3.1294		-2.8140		-2.8140		-2.8140		-2.9720		-3.1218		-2.8140	
10% level	-2.8686		-2.6600		-2.6600		-2.6600		-2.7800		-2.8642		-2.6600	

Appendix 6: Residual Normality Test



Mean	-0.018877	Jarque-Bera	7.194054
Median	-0.020723	Probability	0.027405
Maximum	0.109540		
Minimum	-0.203601		
Std. Dev.	0.050643		
Skewness	0.000257		
Kurtosis	3.628567		



Mean	0.000363	Jarque-Bera	316.5708
Median	-0.000265	Probability	0.000000
Maximum	0.171973		
Minimum	-0.172190		
Std. Dev.	0.039856		
Skewness	-0.020221		
Kurtosis	6.957742		

Appendix 7: Robustness of Results: an Example

Dependent Variable: R&D
Method: Panel EGLS (Period weights)
Sample (adjusted): 1999 2007
Cross-sections included: 83
Total panel (unbalanced) observations: 471
Linear estimation after one-step weighting matrix
Period SUR (PCSE) standard errors & covariance (d.f. corrected)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.05022	0.02176	2.30789	0.02150
cash flow	0.00875	0.02091	0.41813	0.67610
delta debt	0.01688	0.02354	0.71701	0.47380
sales/assets	-0.00681	0.00580	-1.17390	0.24110
ln(assets)	-0.00225	0.00130	-1.73019	0.08430
tobin q	0.00542	0.00205	2.64137	0.00860
r&d lag	0.69581	0.02849	24.42367	0.00000

Effects Specification

Period fixed (dummy variables)

Weighted Statistics

R-squared	0.75115	Mean dependent var	0.10189
Adjusted R-squared	0.74294	S.D. dependent var	0.12511
S.E. of regression	0.06333	Sum squared resid	1.70027
F-statistic	91.41917	Durbin-Watson stat	1.80966
Prob(F-statistic)	0.00000		

Unweighted Statistics

R-squared	0.74176	Mean dependent var	0.08751
Sum squared resid	1.76450	Durbin-Watson stat	1.82531