R&D Activity Investments and Macroeconomic Determinant Factors.

- A Firm-level Investigation of Two Segments of the Electronic Industry in Sweden.

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Abstract

Investments in R&D activities are essential to firms. Decisions to increase or decrease R&D investments may rely according to changes in macroeconomic factors. The purpose of this paper is: to examine how firms in the industries; manufacturing computers, electronics and optics and manufacturing electrical equipment, have increased or decreased their R&D investments, in conjunction with macro factors during the 2000s. The sample is 49 Swedish firms. This paper is based on quantitative firm-level panel data on R&D activity investments and aggregated quantitative macro-level data on macro factors. The firm-level panel data set has been put together completely from scratch, using collected and transformed raw data. Using a logistic regression model, the results show that macro factors do affect R&D investments on a micro-level, to some extent. Further, the results show that change in macro factors does to a greater extent, affect decreases in R&D investments than increases in R&D investments. The process of increase and decrease of R&D investment should be considered as two different dynamic processes. Increase and decrease do not follow the same pattern, thus a decrease of R&D investments is a more explicit decision than a decision to increase R&D investments.

Keywords: R&D investment, Macroeconomic factors, R&D increase, R&D decrease
Acknowledgement

This is a master thesis in business administration. Beside me many people are involved and have in different ways and extent contributed to this thesis.

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1. Introduction

This paper is about R&D activity investments on a firm-level. Decisions about R&D investments are based on many factors. These may be factors in the market such as competition or individual management interests. Macroeconomic factors may also affect decisions about R&D investments. Decisions to increase or decrease R&D investments may rely according to changes in macroeconomic factors. It must be clarified that this paper focuses on these macroeconomic factors. The R&D investments in two segments of the Swedish electronic industry are investigated during years 2000-2012. The main research questions of this study are: (1) macro factors do affect R&D investments on a micro-level, but which macro factors do, and to what extent? A second (2) research question is: do macro factors affect decreases in R&D investments to a greater extent than increases in R&D investments? The purpose of this paper is therefore to examine how the firms in these two segments have increased or decreased their R&D investments in conjunction with macro factors during the 2000s. R&D activity investments refer in this paper to investments which make internal research and development possible for firms and, moreover, firms’ investments in patents and licenses. Further, the generalizability of the study is limited due to the population and sample. This should be taken in consideration when reading the results and conclusions.

The contribution of this study is within the second research question. The statistical analysis shows that macro factors do affect decreases in R&D investments to a greater extent than increases of R&D investments. The study also provides further conclusions regarding the first research question and reasoning concerning further research.

The paper is structured as follows: Section 2 provides theoretical premises of why R&D investments are essential. Further, trends of R&D investments, macroeconomics and the electronic industry are presented. Then a case discussion and the purpose of the paper are presented. The section ends with a review of previous relevant research literature. In Section 3, the methodology is presented. It contains a description of the data used, explains how it is used and provides the samples. Section 4 provides the theoretical framework of the paper. Here two main notions are referred to, uncertainty and irreversible investments.
In Section 5 the analysis and results are presented, followed by Section 6 where conclusions are presented.

2. Background

2.1 The importance of R&D investments

Monopolistic and oligopolistic competition can be unfavourable to the capitalist view of maximization of production performance (Schumpeter, 1943). Capitalism favours maximum product performance, which can be achieved in a competitive environment, according to Schumpeter (1943). But when monopolistic structures emerge a lack of competition can occur and this may possibly affect performance.

"The fundamental impulse that sets and keeps the capitalist engine in motion comes from the new consumers’ goods, the new methods of production or transportation, the new markets, the new forms of industrial organization that capitalist enterprise creates.” (Schumpeter, 1943 p.83)

The development of new goods, methods, markets etc. contributes to changes and revolutions in industries and in the entire economic structure. Schumpeter (1943) writes, “…incessantly destroying the old one, incessantly creating the new one”. What is meant is that the evolution and development of new goods, methods, markets, etc. replaces the old ones. This process is what makes industries and economic structures move forward and not stagnate. The process is known as creative destruction and it is, according to Schumpeter (1943), the essential fact about capitalism. Evolution and the development of new goods, methods, processes etc. are essential ingredients of economic structures on several levels, both macro and micro. Research and development (R&D) becomes a key factor in moving economic structures forward and the key factor for any specific firm in search of innovation. The following statement is not particularly controversial, namely that new goods, markets, processes or other possible innovations start with or require research and development activities (R&D). Further, carrying out R&D activities makes some sort of investment inevitable. That is not a particularly controversial statement either. Therefore, it can be said that investments are essential to carrying out R&D activities which may lead to inventions and hopefully in the end to creating innovations.
There are different opinions as regards innovation efficiency and factors as to why and how different types of firms invest in R&D activities. Efficiency aims in this context to maximize the amount of innovation output per R&D activity input. The early works of Schumpeter (1934) emphasized the importance of innovative success among small and medium-sized enterprises (SMEs). He argued further, still in his early work, that SMEs were the main source of innovation. Schumpeter (1934) claimed that innovation often emerged in small, young and/or entrepreneurial firms. These types of firms acted from more diverse circumstances and activities. These were the grounds for his reasoning.

Later, Schumpeter (1942) returned to the same topic but used a different argument. Market imperfections lead to advantages for larger firms. This is because instability and risk appear to be less in their R&D projects. Firm size appears to correlate with stability. R&D activities can be very costly for small firms due to the differences in access to resources. This, and the fact that it is less demanding to be a follower led Schumpeter (1942) to the hypothesis that small firms did not choose to participate in R&D projects to the same extent as large firms, or put in another way, “SMEs may be less likely to invest in R&D activities than larger firms.” (Ortega-Argiles, et al., 2009 p.4). An additional advantage in being a large firm is the possibility of spreading risks by not being forced to rely on only one or a few specific R&D projects (Ortega-Argiles, et al., 2009). In the long run, investments in R&D activities are motivated by profit. But, compared to other investments, there are considerably more uncertainties involved with investments in R&D activities (Ortega-Argiles, et al., 2009 p.4). It is difficult to predict outcome and maximize pay-off and this influences decision making (Scherer et al., 2000). This can also be a factor where firm size is of importance. However, it is necessary to make a reservation against official statistics as regards R&D and the risk of underestimated innovation in small firms. It is more likely that large firms engage in formal R&D than small firms (Ortega-Argiles, et al., 2009). But efficiency seems to be better in SMEs than in large firms, at least according to patent applications made. The R&D input generates innovation output more efficiently in SMEs than in large firms (Acs and Audretsch, 1990; Van Dijk et al., 1997). Obviously, these are general statements and there are other variables that are of importance, i.e. sectorial belonging (Ortega-Argiles, et al., 2009).

There are obviously different strategies when it comes to R&D investments, or more precisely, different strategic dimensions of R&D activities. An example could be the extent
to which a firm invests in internal R&D. Differences, in a time perspective, depending on whether the R&D project is temporary and limited in scope or for an indefinite period of time. Other strategic dimensions might be if the R&D activities are carried out with the aim of generating a specific outcome in a specific R&D project or if the R&D activities are more of an explorative nature.

Traditionally, when it comes to inventions and products and process development, investment in internal R&D has been the focus in many firms. This kind of R&D is no longer the obvious main or primary source (Berchicci, 2012; Smith, 2006). When it comes to development and inventions, investments in various sources of R&D become more common (Smith 2006; Ransbotham and Mitra 2010). The changes in the allocation of R&D investments are supported by Smith (2006), “It \.../ reflects the changing nature of innovation, especially the increased importance of knowledge and the various different ways in which that knowledge can be channelled into innovation.” (Smith, 2006 p.104). Further, there is a growing and upcoming trend in the external acquisition of technology (Ransbotham and Mitra, 2010). This applies especially to high-technology industries. Intangible resources among firms are being acquired, combined and exploited in various ways (Granstrand, 1999). The strategy can be to use the acquisition as a complement to internal R&D (Ransbotham and Mitra, 2010). This change in inventing and product development has its origins partly in the increasing time-to-market pressure and the shortening of product life cycles (Ransbotham and Mitra, 2010). The development of markets (especially high-technology markets) leads to external acquisition playing a major role in firms’ product development processes (Higgins, Rodriguez, 2006).

2.2 Trends in R&D investments and patent applications
This section presents trends in R&D investments and patent applications. Data is presented on two levels, the national level and an industry based level. The majority of the data in the following section is taken from the Main science and technology indicators (MSTI) reports, published by the OECD and the Swedish official agency of statistics (SCB). The MSTI-reports presents various indicators concerning the level of R&D and R&D trends in the OECD countries and some non-members of the OECD. The unit of measure presented is the Gross Domestic Expenditure on Research and Experimental Development (GERD) and the
Expenditure on Research and Experimental Development in the Business Enterprise Sector (BERD).

All values in this section (2.2) are on an aggregated macro level. This may cause complications when interpreting these values. It is therefore important not to draw conclusions in individual cases. Aggregated data can be affected by changes on a non-aggregated level. My point is that if a total industry were to suffer the severe impact of an economic downturn, it would affect the aggregated data, but it would not necessarily affect other industries. The values in this section can be affected in this way. This is a natural disadvantage with this kind of data and hard to reduce, therefore it is relevant to keep this in mind when approaching the data in this section.

As regards Swedish R&D investments from an overall perspective, a general increase in investments over the last three decades is clearly visible. There has been an almost constant increase in R&D investments since the early 1980s, as read in table 1. The increase has five exceptions, 1991, 2003, 2007, 2009 and 2010. An explanation for this can be periods of fluctuations in the economy, especially 2003 and 2009-2010. These periods are described more thoroughly in section 2.3 below.

Table 1– Gross domestic expenditures on R&D (GERD) in Sweden, (constant price, KPI 1980 = 100, million USD).

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure</td>
<td>1818</td>
<td>1920</td>
<td>2154</td>
<td>2284</td>
<td>2245</td>
<td>1986</td>
<td>2181</td>
<td>2454</td>
<td>2778</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>1999</th>
<th>2001</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure</td>
<td>3173</td>
<td>3849</td>
<td>3720</td>
<td>3739</td>
<td>3729</td>
<td>4164</td>
<td>4033</td>
<td>4513</td>
<td>4130</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure</td>
<td>4043</td>
<td>4198</td>
</tr>
</tbody>
</table>

Source: OECD 2012

Sweden, when compared to other countries, tops the list of gross domestic expenditures on R&D as a percentage of gross domestic product (GDP), according to MSTI (2012). In comparison to other OECD countries, Sweden has the fourth (relative) largest R&D investments, more than countries as Japan, Germany and USA. Most of the total R&D
performance in Sweden has been made by the business enterprise sector (MSTI, 2012 p.36). Between the years of 2006 and 2011, the percentage has been between 74.7% and 68.7%. This rate tops the list compared with the other OECD countries.

Total investments in R&D within the business enterprise sector, as read in table 2, dipped in the early 2000s. In the middle of the decade there was an increase for a couple of years only to stagnate or decrease after 2007.

Table 2 – Total expenditures in R&D within the business enterprise sector (constant price KPI 1980 = 100, million SEK).

<table>
<thead>
<tr>
<th>Year</th>
<th>2001</th>
<th>2003</th>
<th>2005</th>
<th>2007</th>
<th>2009</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenditure</td>
<td>27879</td>
<td>25826</td>
<td>25444</td>
<td>26441</td>
<td>26300</td>
<td>25778</td>
</tr>
</tbody>
</table>

Source: SCB 2012

In the tables (3, 4 and 5) below, statistics and trends concerning patents are presented. The most visible trend that can be discerned is the change in where, geographically, patent applications are submitted. Table 3 shows the number of applications made to the PRV (the Swedish Patent Registration Office), where the applicant is registered in Sweden (PRV, 2013). During the last decade there has been a steady decrease in the number of patent applications made during the circumstances described above.

Table 3 – Swedish patent applications to the PRV in Sweden.

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications</td>
<td>4135</td>
<td>3798</td>
<td>3308</td>
<td>3003</td>
<td>2728</td>
<td>2498</td>
<td>2429</td>
<td>2517</td>
<td>1386</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications</td>
<td>2151</td>
<td>2195</td>
<td>2004</td>
</tr>
</tbody>
</table>

Source: PRV 2013

In tables 4 and 5; EPO-Euro shows the number of European applications made from Sweden. USPTO shows the number of applications to the USPTO (Utility Patent) in which the first named inventor is from Sweden. Contrary to the decrease in the number of Swedish national patent applications, international patent applications with Swedish applicants have increased over the same period of time. This shows a trend of an increasing number of patent applications in Europe by Swedish applicants and, a trend of a decreasing number of patent applications in Sweden, by Swedish applicants.
Table 4 – Applications to EPO-Euro and USPTO, Swedish applicants.

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications EPO-Euro</td>
<td>495</td>
<td>511</td>
<td>489</td>
<td>576</td>
<td>591</td>
<td>693</td>
<td>636</td>
<td>684</td>
<td>753</td>
</tr>
<tr>
<td>Applications USPTO</td>
<td>2825</td>
<td>2827</td>
<td>2410</td>
<td>2314</td>
<td>2270</td>
<td>2243</td>
<td>2680</td>
<td>3164</td>
<td>3265</td>
</tr>
</tbody>
</table>

Year | 2009  | 2010 | 2011
<table>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Applications EPO-Euro</td>
<td>601</td>
<td>969</td>
<td>1122</td>
</tr>
<tr>
<td>Applications USPTO</td>
<td>3515</td>
<td>3840</td>
<td>4140</td>
</tr>
</tbody>
</table>

Source: PRV 2013

Table 5 – Patent applications

Source: PRV 2013
2.3 The economic situation
Swedish economic growth, measured by GDP, has increased on an average of about 2 % since the 1970s (ekonomifakta.se). The economic situation has not, however, been plain sailing. A number of economic crises have hit the Swedish economy during this period.

After several years of positive growth (especially during the 1980s), Sweden underwent a major recession in the 1990s. The crisis affected the real estate market, the financial market and the banking sector (finanshistoria.n.nu). Growth (GDP) was negative in 1991-1993, and the effect of the crisis persisted for a further few years. Economic recovery did not occur rapidly, due to the negative economic situation globally. Sweden started to show positive economic results during the late 1990s. However, in the 2000s, the country experienced two major crises. The IT-industry was booming but became overvalued and during 2000-2001 the bubble burst, causing a severe downturn in the Swedish economy. The second major crisis was the financial crisis in the autumn of 2008. This crisis escalated from the financial sector and stock markets were hit hard by it. Banks and firms were faced with considerable liquidity problems (2008/09:SkU27). Thus, in 2009 Sweden’s GDP declined by 5 %. This is the largest decline of the Swedish GDP in a single year in modern times. There has been a recovery since the financial crisis, the year 2010 especially showed high growth rates. But, as the international debt crises worsened, the Swedish economy slowed down again (ekonomifakta.se).

2.4 The electronic industry
The population of this study is within the Swedish electronic industry. The historical development of the industry has of course been affected by the economic crises just mentioned above. The crisis in the early 90s hit the electronic industry hard in terms of bankruptcies (ekonomifakta.se). In the years following this crisis the number of bankruptcies was high, with a top notation in 1996 when the increase from the year before was 46 % (scb.se). During the second half of the 90s the rate of bankruptcy decreased. The IT-crash had a severe impact on the industry as a whole, which led to the rate of bankruptcy increasing in 2001 by 53 % and in 2003 by 32 % (scb.se). These years stand out. During the middle of the 2000s the industry flourished. The bankruptcy rate was low. Later, the effect of the financial crisis in 2008 damaged the industry and bankruptcies increased in 2009 (32 %) and 2010 (25%) (scb.se). The general implication is that the industry has been re-
organized to some extent in terms of the number of firms on three occasions during the past 20 years.

Two segments of the total industry are in focus, C26 and C27, according to the SNI2007 classification. These two segments are considered as the total population of the study, which consists of 362 firms. The firm size distribution in the two industry segments can be read in table 6. The population consists mostly of micro and small firms\(^1\), although, medium-sized and large firms dominate when comparing these firms’ turnover to the total turnover of the population.

Table 6 - Firm size distribution of the population

<table>
<thead>
<tr>
<th>EU SME category</th>
<th>Firms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Micro</td>
<td>221</td>
</tr>
<tr>
<td>Small</td>
<td>105</td>
</tr>
<tr>
<td>Medium-sized</td>
<td>42</td>
</tr>
<tr>
<td>Large</td>
<td>25</td>
</tr>
</tbody>
</table>

*Source: Retriever Business*

When considering the age of the firms in the population, the date of registration of the firm is the value considered. About 2/3 of the firms in the population are under 40 years old. About 1/3 of the firms in the population are less than 20 years old.

In terms of turnover a few firms dominate the industry, when compared with the total turnover of the industry. Eight firms out of a total of 362 firms account for 47 billion SEK of the industry’s total turnover of 62 billion SEK (2011). Or presented as a percentage, 2 % of the firms account for 68 % of the industry’s total turnover (2011) (retriever business).

The C26 segment includes the manufacture of computers, computer peripherals, communications equipment, and similar electronic products, as well as the production of components for such products. This segment also includes the manufacture of consumer electronics, measuring, testing and navigation equipment, radiological, electromedical and

\(^1\) The SME categorization of firms takes the number of employees and turnover or balance sheet total in consideration. The values of the categories are as follows: Micro; employees < 10 and turnover < € 2 million or balance sheet total < € 2 million. Small; employees < 50 and turnover < € 10 million or balance sheet total < € 10 million. Medium-sized; employees < 250 and turnover < €50 million or balance sheet total < € 43 million. Firms with larger values than the medium-sized category are considered as large firms.
electrotherapeutic equipment, optical instruments and equipment, and the manufacture of magnetic and optical media (scb.se). The C27 segment includes the manufacture of products that generate, distribute and use electrical power. In addition, the main group also includes the manufacture of electrical lighting, signalling equipment and electrical appliances (scb.se).

The sampling of firms resulted in a selection of 49 firms. These 49 firms reflect the population as regards firm size, firm age and segment. There has been shown how Sweden has had a recession in its economy during 2008 and 2009. The sample of 49 firms that represent the two industry segments has also been affected by this crisis. In 44 of 49 firms there was a decrease in turnover during this period. When compared with other years, the years 2008 and 2009 stand out, especially 2009. The average decrease of turnover during 2009 was about 9 % (retriever business). When considering the number of employees the period from 2008 to 2010 stands out. 36 of the 49 firms made cutback in their personal during this period. About half of the 49 firms made cutback in at least two of these three years (retriever business).

2.5 The Case - Problem discussion and purpose
Investments in R&D activities are essential to create new inventions such as processes, goods, new markets, etc. R&D activities become a key factor to move the economic structure forward. The process of creative destruction is the process that keeps markets from stagnation and ensures continued development, according to Schumpeter (1943). This process of creative destruction is closely related to R&D activities.

Overall, R&D investments in Sweden have increased during the past three decades. There has been a constant increase with a few exceptions, the early 2000s and the late 2000s. Sweden spends large sums on R&D activities relative to GDP, compared to other countries and Swedish firms’ patent applications have decreased nationally but increased internationally during the same period.

The economically weak periods during the last decade (the 2000s) seem to have affected the two industry segments, the manufacturing of computers, electronics and optics (SNI2007-code C26) and the manufacturing of electrical equipment (SNI2007-code C27) in two ways, i.e. decrease in turnover and personal.
Furthermore, it has been shown that firms have decreased their R&D investments during these same periods. This happened, despite the fact that R&D is probably the most important factor in creating inventions and, hopefully, innovations. The question is naturally, why do the R&D investments decrease? This may be due to macro factors, such as economic crises, interest rates, stock markets or due to micro factors such as changes in management or a combination of both. The question the follows is, how do these factors affect R&D investments? The focus of this paper is to clarify which and to what extent macro factors affect R&D investments.

The research questions or assumptions of this study are: (1) macro factors do affect R&D investments on a micro-level, but which macro factors do, and to what extent? A second (2) question or assumption is that macro factors do affect decreases of R&D investments to a greater extent than increases of R&D investments. The purpose of this paper is therefore: to examine how firms in the industries; manufacturing computers, electronics and optics and manufacturing electrical equipment, have increased or decreased their R&D investments, in conjunction with macro factors during the 2000s.

2.6 Literature Review
Firms act in different ways in response to macroeconomic fluctuations. One stream of literature focuses on the extent to which economic downturns or recessions impact on innovation on a national level (Archibugi and Filippetti 2010; Archibugi and Filippetti 2011; Maskus, Neumann and Seidel 2011). They use aggregated- and firm-level data in their research to reach conclusions on a national level and to some extent on a meso- and/or micro-level. Results that can be deduced from both these studies are the extent to which nations, industries or firms that are affected differ from each other. Archibugi and Filippetti (2010; 2011) conclude that emerging nations are the most vulnerable to macroeconomic downturns. Sweden is not considered one of these emerging nations. Still, Sweden, among other non-emerging nations, is affected, but relatively less so. Archibugi and Filippetti (2010) also come to the same conclusions on a micro level, stating that a crisis, like the financial crisis of 2008, affects firms to different degrees. Many firms managed to keep their investments in innovation steady and unchanged. Firms able to expand their investments decreased and firms that reduced investments increased substantially. Maskus et. al. (2011) concludes that differences in how firms in 18 OECD nations are affected as regards their
R&D are due to country-wide financial development. These differences depend on the sources of the investments. The largest impact is due to dependence on bond-markets, and firms that are closely attached to these markets and also rely in externally financed investments. It is interesting to note that other literature finds that firms relying on internal investments are the ones to suffer most. This is because there are many ways of seeking financial input externally and probably not all external sources are affected to the same extent.

A second stream of literature focuses on the degree to which macroeconomic dynamics affect investment in R&D on a firm level (Kuznetsov and Simachev 2010; Masino 2012; Cincera, Cozza, Tubke and Voigt 2011; Thompson and Stam 2010). The level of data used varies between aggregated data and panel data. The overall and frequently reappearing conclusion that is drawn is that changes in macro factors affect R&D investments in firms to different extents. Thompson and Stam (2010) use macroeconomic factors such as domestic consumption, interest rates and real GDP for their purpose. GDP growth is used as a primary factor to identify the macroeconomic conditions. Their conclusion is that most industries and firms invest in their R&D activities in turn with macroeconomic cycles. Of course there are variations. Industries and firms that are very innovation dependent reduce their R&D investments less than those that are not so innovation dependent. Cincera et. al. (2012) investigates firms’ R&D investments during economic crises. Their question is if firms spend more or less on R&D activities during recession. Their overall results were that a large number of the firms examined reduced R&D investments during crisis. There was a variation as to which firms were affected the most. Large firms and also the smallest firms seemed to be the least affected.

A third stream of literature investigates how R&D investments can be cyclical in conjunction with macro factors (Aghion et. al. 2008; Rafferty and Funk 2008; Bohva-Padilla et. al. 2009). The general conclusion of their research is that R&D investments are to some extent cyclical and affected by changes on a macro level. Aghion et. al. (2008), using firm-level data, find that credit constraints and recession are factors that affect firms’ R&D investments negatively. Rafferty and Funk (2007) state that firms rely on “cash flow” to invest in R&D activities. Cash flow constraints are likely to occur during recession and this can lead to reduced investments.
3. Methodology

3.1 The data
This paper is based on quantitative firm-level panel data on R&D activity investments and aggregated quantitative macro-level data on macro factors. The firm-level panel data set has been put together completely from scratch, using collected and transformed raw data. The macro-level data has also been put together from scratch, collected as raw data and transformed. A few indicators were already complete indexes. These are merged into the data set.

The source of the micro-level data is the firms’ annual reports. The availability of annual reports is complete for all firms and in all required years (2000-2012). The values of the indicators of interest are collected from every firm and year for the time period of this study. The indicators in the annual reports that are of interest are research and development expenditures (forsknings- och utvecklingskostnader) in the income statement and capitalized research and development expenditures (balanserade forsknings- och utvecklingskostnader) and intangible assets (immateriella anläggningstillgångar) in the balance sheet. Even though the availability of annual reports is complete, there are some missing values in the data. This indicates either that the firms do not report values some years or that there are no investments some years. When it comes to R&D expenditures and capitalized R&D expenditures, firms tend to use either one or the other when presenting indicators regarding R&D. The macro-level data are collected from several sources, PRV, Konjunkturinstitutet, SCB, Riksbanken, Ekonomifakta and NasdaqOMX.

3.1.1 Indexes and Logarithms
This paper has as its aim to find patterns over a period of time as to how firms act in their R&D investments. This means that a change from one year to another is of interest. To show this change, the raw data values are transformed into an index. The index values are thereafter transformed into logarithms, so as not to get an unnecessary difference in the index values. Transforming into logarithms is also made so as to prevent heteroscedasticity to a greater extent (Djurfeldt et. al. 2003).
3.1.2 Merging indicators to a variable.
The three indicators (mentioned above in 3.1) are merged and create one variable that is used as the dependent variable, *R&D Investments*. There are no complications in merging different indicators into one variable in this case. This is because individual cases are not compared to each other, but are compared to independent variables. This means that if case nr 1 (firm nr 1) uses the *research and development expenditures* indicator and case nr 2 (firm nr 2) uses the *capitalized research and development expenditures* indicator it does not matter because case no 1 and case no 2 (or any other case) are not compared individually to each other. This merged variable, *R&D Investments*, is compared with macro factors connected to the economic situation during the same period, 2000 to 2012.

3.1.3 The statistical method
The statistical method used in this paper is *binary logistic regression analysis* (Djurfledt et. al. 2003). This method is used because the aim of this paper is to show how firms increase or decrease their R&D investments and because this aim allows the use of a dichotomous dependent variable. In this paper the dichotomous variable shows if R&D investments increase or decrease. Something that should be taken into consideration when transforming data into a dichotomous variable is the categorization of the data. The variable measures only the increase or the decrease, but not to what extent. Therefore, variations in increasing and decreasing R&D investments can be extensive.

The statistical program SPSS is used to carry out the logistic regression analysis. Descriptions of the analysis of the regression model are also presented in the analysis and result section (5.1) in conjunction with the interpretations.

3.1.4 Lagged variables
One factor that is taken into consideration and adjusted for is the time aspect of cause and effect. More precisely, the value that is measured and represents the macroeconomic factor in a specific year may not have a strong relation to the investments in R&D activities in exactly the same year. However, it is likely that a change in the values in a specific year affects investments in R&D activities one or two years later. An example may make it clearer: A firm’s economic results drop from 2000 to 2001. This decrease may not affect investments in R&D activities the same year, but obviously may affect future investments, such as investments in 2002. The point is that to find the result of a cause and effect
relation, the values from exactly the same year may not be the optimal way of comparison. Thus, there is a delay of one year in the time aspect in the comparison of the values. As an example, the economic situation value of 2000 is compared to investments in R&D activities in 2001. Therefore, the values of the macro factors are “lagged” with x years (t-x). Variables are lagged one to two years (t-1, t-2).

3.2 Population and sample
The population of this study is within the Swedish electronics industry. To be more specific, two segments of the electronics industry have been chosen. The Swedish corporate sector, depending on its core business, is classified in a system called SNI 2007. Every segment is clearly defined and classified and has its own SNI code. The two segments chosen in this study are the manufacturing of computers, electronic and optical products (SNI C26) and the manufacturing of electrical equipment (SNI C27). To narrow these two segments, only a limited number of firms are included in the sample. The selection is based on the following premises: The legal form of the firm, firm age, number of employees, turnover and the availability of data. Firms with the legal form of a joint-stock company have been selected. Firms registered before the year of 2000 are included, because of the time perspective of the paper. This is a longitudinal study ranging from the year 2000 to 2012 and thus it is obvious to include firms registered before this date. When it comes to the number of employees the firms have a minimum of one employee. Firms with no registered employees can often be inactive and therefore not of interest. For the same reason, firms with more than one million SEK in turnover are included. Based on these premises the total population of this study consists of 362 firms. Of these 362 firms a sample is made based on the availability of data. The sample is also made under the premise that the data is presented in the parent firms’ annual report and not in any consolidated accounts. This selection was inevitable when making this study and resulted in a sample of 49 firms. The distribution of the samples within the population is representative due to a spread of firm age, number of employees and turnover.
4. Theoretical framework

Two main notions are referred to in this paper are, uncertainty or risk and irreversible investments. Arrow (1968) suggests that during periods of certainty, irreversibility creates “...a wedge between the cost of capital and its marginal contribution to profits.” But, during periods of uncertainty, irreversibility can play an important part in decisions concerning investments, according to recent literature (see further below).

Investments are often irreversible. Irreversible investments in this sense mean that when the investment has been made it cannot be remade or unmade (Pindyck, 1986). Making the investment is connected to choosing an option as Pindyck (1986) states, “Given this irreversibility, one must view an investment expenditure as essentially the exercising of an option (an option to productively invest)” (Pindyck 1986 p.4). The general statement by Pindyck (1986, 1991) is that decisions about investments are sensitive to conditions of uncertainty and changes of risk. There is always an option of when to invest or even if to invest. But, when an investment has been made the possibility of evaluating this decision with more information is lost. Researchers (McDonald and Siegel 1986; Bernanke 1983; Pindyck 1986, 1991; Bertola 1998) deal with the notion of irreversible investments. The general topic in their research is when to invest and what factors might affect investment decisions.

Irreversible investments are closely connected to risk and/or uncertainty. Uncertainty about future and on-going conditions is a factor to take into consideration when considering cyclical aggregated irreversible investments (Bernanke 1983). Further, Bernanke (1983) presents two arguments for investment fluctuations that can arise from the relationship of irreversibility and uncertainty. The first argument concerns macro-level factors. Macro-level factors are important in investment decisions on a micro-level, because of the possible negative effect that macro-level factors could have on a micro-level. Bernanke (1983) refers to the following macro-level factors, i.e. monetary changes, conditions of trade and competition, fiscal changes or other policy changes. These macro factors can affect investments either on an aggregated level, an industrial level or a micro level. This argument works on the supposition that uncertainty is exogenous to the economic system. The second and alternative argument is that uncertainty can be developed from within the economic
system. Fluctuations in demand on an aggregated level can exist i.e. depending on tastes or technology. These fluctuations on an aggregated level can influence demand on a micro level. This may have an effect on when or if irreversible investments are made. These possible reduced investments may affect other parts of the economy and cause a chain reaction. In the same way Pindyck (1986) and Bertola (1989) state that increased volatility in demand can often lead to a decrease in investments.

Fazzari, Hubbard and Petersen (1988a) and Hubbard (1990) also present a similar kind of argumentation and thesis, that financing constraints in capital markets affect investments. Financing constraints in capital markets could in this sense be seen as a macro factor. Their argumentation shows that, fluctuations in macroeconomic cash flow are correlated with movement in the business cycle, and further, that instability on a macroeconomic level could affect investments in firms. In a similar way, Serven and Solimano (1992) say that a stable macroeconomic environment could be important in investment decisions.

4.1 Conceptualization

Here follows a conceptualization of why this theoretical framework is used when examining the paper. During periods of the 2000s in Sweden there have been, as shown above, dips in the economic situation, such as the IT-crash in 2001 and the financial crisis in 2008. It is natural to claim that these were periods of uncertainty, with decreasing demand, turn-over in industries, etc. It has also been stated that conditions of uncertainty is connected to, and a factor, in decisions concerning investments, i.e. investments in R&D activities. Therefore, it is highly possible that these periods of uncertainty have affected R&D investment decisions in the industry segments, (C26) manufacturing of computers, electronics and optics and (C27) the manufacturing of electrical equipment. The theoretical framework of uncertainty and irreversible investments is, because of these arguments suitable and relevant to the purpose of this paper.
5. Analysis and Results

In this section the analysis is made and the results are presented.

5.1 Logistic regression model

Binary logistic regression is used to predict what affects the firms’ increase or decrease in R&D investments. The dependent variable in the logistic regression is labelled *R&D Investments*. The variable is dichotomous and, therefore coded as follows: *decrease* in R&D investments is 0.00 and *increase* in R&D investments is 1.00.

The logistic regression model can be interpreted in different ways using different indicators. This regression model is interpreted as follows: The variance or the rate of explanation of the model can be interpreted by different indicators (-2 log likelihood, Cox & Snell R2 and Nagelkerke R2). In this paper another indicator is used to present the rate of explanation, namely the predicted values in contrast to the observed values in the *classification table*, in SPSS. Further, when interpreting the coefficients, the b-coefficient is the indicator considered. When interpreting the b-coefficient in the logistic regression model an *odds* is calculated (Miles & Shevlin 2001). An odds is the probability that something will occur divided with the probability that it will not occur. The b-coefficient in a logistic regression shows the change in the natural logarithm (Ln) (all variables used in the regression model are transformed into natural logarithms) of the odds of the dependent variable which has the coded value of 1.00. The odds is calculated as follows: If an independent variable increases by one unit, the Ln. of the odds increases or decreases (depending on a positive or negative b-coefficient) of a firm increasing R&D investments with the b-coefficient. Converted to a percentage it means that the odds of the dependent variable being 1.00 (Increase R&D investments) decreases with (b*100). It is important to mention that the percentage is approximate and also that the percentage should not be read as percentage points, rather as a per cental change.
5.1.1 The degree of explanation

Table 7 – Classification table.

<table>
<thead>
<tr>
<th>Observed</th>
<th>Predicted</th>
<th>Percentage Correct</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RD_Investments</td>
<td></td>
</tr>
<tr>
<td>.00</td>
<td>163</td>
<td>72</td>
</tr>
<tr>
<td>1.00</td>
<td>76</td>
<td>105</td>
</tr>
</tbody>
</table>

a. The cut value is .500

The classification table shows the predicted classification of each case (firm and year) based solely on the distribution of the dependent variable (R&D investment increase or R&D investment decrease). The predicted value in relation to the observed value shows how many predicted cases were observed in the final model. This rate is used to show the explanation rate of the final model. In this model the classification table is interpreted as follows: The model predicted that 235 (163+72) cases would decrease R&D investments, but observed 163 cases of the predicted 235. Thus, 163 out of 235 cases actually did decrease R&D investments. That gives a percentage rate of 69.4% observed cases. Further, the model predicted that 181 cases would increase R&D investments, and it observed 105 cases out of those 181 predicted. That gives a percentage rate of 58.0%. Thus, the model observed more of the cases predicted with R&D decrease than cases predicted with R&D increase, which could indicate that the model explains decreases in R&D investments to a larger extent than increases in R&D investments. The overall percentage rate of predicted cases contrary to observed cases is 64.4%. Thus, when using the classification table, this final model successfully predicts 64.4% of the cases.
5.1.2 Interpretation of the model

Table 8 – Logistic regression model for R&D investment increase or decrease.

<table>
<thead>
<tr>
<th>Variables</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D Investments (t-1)</td>
<td>0.825</td>
<td>0.802</td>
<td>0.809</td>
<td>0.848</td>
<td>0.836</td>
<td>0.830</td>
<td>0.821</td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
<td>(0.000)</td>
</tr>
<tr>
<td>Large Firm</td>
<td>0.410</td>
<td>0.415</td>
<td>0.435</td>
<td>0.424</td>
<td>0.431</td>
<td>0.480</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.139)</td>
<td>(0.135)</td>
<td>(0.120)</td>
<td>(0.131)</td>
<td>(0.126)</td>
<td>(0.099)</td>
<td></td>
</tr>
<tr>
<td>OMXS 30 (t-1)</td>
<td>0.588</td>
<td>0.746</td>
<td>0.445</td>
<td>0.908</td>
<td>1.435</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.165)</td>
<td>(0.120)</td>
<td>(0.336)</td>
<td>(0.106)</td>
<td>(0.015)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lending and deposit interest rate</td>
<td>-0.568</td>
<td>-0.758</td>
<td>-1.078</td>
<td>-0.998</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.005)</td>
<td>(0.001)</td>
<td>(0.001)</td>
<td>(0.003)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crisis (t-1)</td>
<td>-0.569</td>
<td>-0.981</td>
<td>-0.845</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.081)</td>
<td>(0.022)</td>
<td>(0.050)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repo interest rate</td>
<td>-0.335</td>
<td>-0.636</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.138)</td>
<td>(0.009)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long interest rate</td>
<td>3.793</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(0.000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall observed of predicted cases (%)</td>
<td>59.9</td>
<td>59.9</td>
<td>61.3</td>
<td>61.5</td>
<td>62.7</td>
<td>61.1</td>
<td>64.4</td>
</tr>
</tbody>
</table>

Each independent variable is described below. Further the b-coefficient is interpreted and the odds is calculated. Also the significance is presented.

The variable, **R&D Investment (t-1)**, is the dependent variable used as an independent variable and lagged one period (1 year). This variable is included in the model as a control variable. Also, it is included because of the likelihood of the investment year one affecting the investment year two. When interpreting the b-coefficient, a positive relation is shown. This means that earlier R&D investments affect future R&D investments. The odds is calculated: If **R&D investment (t-1)** increases with one unit, the Ln. of the odds increases with 0.821 of a firm increasing R&D investments. This means that the odds (converted in percentage) of an increase of R&D investments, increases with about 82.1%. The variable is significant on the 95% confidence level (p<0.05), which means that it is independently correlated with the constant (Djurfeldt et. al. 2003 pp.338), R&D investments, in the final model.
Large Firm is a dichotomous variable which distinguishes large firms from micro, small and medium-sized firms. The interpretation of the b-coefficient indicates that there is a positive relation between firm-size and R&D investment. The odds is calculated: If the firm is considered to be large the Ln. of the odds increase with 0.480 of a firm increasing R&D investments. This means that the odds (converted to a percentage) of an increase of R&D investments, increases with 48.0%. The variable is significant on the 90% confidence level \( p < 0.10 \), which means that it is almost independently correlated with the constant (Djurfeldt et. al. 2003 pp.338), R&D investments, in the final model.

The variable OMXS 30 \((t-1)\) is the NasdaqOMX Stockholm stock-market. The variable indicates the stock-market index. In the model the variable is lagged one period (1 year). When interpreting the b-coefficient a positive relation is shown. This means that when the stock-market index increases, R&D investments increase. The odds is calculated: If OMXS 30 \((t-1)\) increases with one unit, the Ln. of the odds increase with 1.435 of a firm increasing R&D investments. This means that the odds, (converted to a percentage) of an increase of R&D investments, increases with 143.5%. The variable is significant on the 95% confidence level \( p < 0.05 \), which means that it is independently correlated with the constant (Djurfeldt et. al. 2003 pp.338), R&D investments, in the final model.

The variable, Lending and deposit interest rate \((t-1)\), is the Swedish Riksbanks interest rate at which they lend to other banks. The interest rate that banks lend at is obviously a reason for the interest rate that firms lend money to. Interpreting the b-coefficient shows a negative relation between the lending and deposit interest rate and the constant R&D investments. This means that when the interest rate increases R&D investments decrease. The odds is calculated: If Lending and deposit interest rate \((t-1)\) increase with one unit the Ln. of the odds decrease with -0.998 of a firm increasing R&D investments. This means that the odds (converted to a percentage) of an increase of R&D investments, decreases with 99.8%. The variable is significant on the 95% confidence level \( p < 0.05 \), which means that it is independently correlated with the constant (Djurfeldt et. al. 2003 pp.338), R&D investments, in the final model.
The Crisis \((t-1)\) variable indicates years when crises have occurred, in this case 2008 and 2009. In the model the variable is lagged one period (1 year). In the interpretation of the \(B\) coefficient in the model a negative relation appears. It can be said that when a year is considered a year of crisis, the R&D investments decrease. Take into account the lag of one year. This shows that the effect is delayed. Thus, a crisis year affects a decrease in R&D investments the year after. The Crisis variable was tested with other lagged periods as well, one year after \((t-0\) and \(t-2)\) but no significance was found. The odds is calculated: In a crisis year, the Ln. of the odds decrease with -0.845 of a firm increasing R&D investments. This means that the odds (converted to a percentage) of an increase of R&D investments, decreases with 84.5%. The variable is significant on the 95% confidence level \((p<0,05)\), which means that it is independently correlated with the constant (Djurfeldt et. al. 2003 pp.338), R&D investments, in the final model.

The variable, Repo interest rate, is the Swedish Riksbanks steering interest rate. When interpreting the \(b\)-coefficient in the model, a negative relation is shown. Thus, when the repo interest rate increases the R&D investment decreases. The odds is calculated: If the Repo interest rate increase with one unit, the Ln. of the odds decrease with -0.636 of a firm increasing R&D investments. This means that the odds (converted to a percentage) of an increase of R&D investments, decreases with 63.6%. The variable is, in the final model, significant on the 95% confidence level \((p<0,05)\), which means that it is independently correlated with the constant (Djurfeldt et. al. 2003 pp.338), R&D investments, in the final model.

The variable, Long interest rate, is an interest rate which projects expectations on the market and the inflation rate. The interpretation of the \(b\)-coefficient shows a positive relation between the long interest rate and R&D investments. When the interest rate increases, R&D investments increase. The positive relation between these two variables was expected, due to the long interest rate meaning in itself, that it indicates expectations of the market. The reason to include it nevertheless in the final model is due to the increase in the degree of explanation of the final model. The odds is calculated: If Long interest rate increase with one unit, the Ln. of the odds increases with 3.793 of a firm increasing R&D investments. This means that the odds (converted to a percentage) of an increase of R&D investments, increases with 379.3%. The variable is, in the final model, significant on the 95% confidence
level \( (p<0.05) \), which means that it is independently correlated with the constant (Djurfeldt et al. 2003 pp.338), R&D investments, in the final model.

To summarize the results, in term of relationships: Four independent variables, \textit{R&D investments \( (t-1) \)}, \textit{Large firm, OMXS 30 \( (t-1) \)} and \textit{Long interest rate}, have a positive relation to R&D investments. Three independent variables, \textit{Lending and deposit interest rate \( (t-1) \)}, \textit{Crisis \( (t-1) \)} and \textit{Repo interest rate}, have a negative relation to R&D investments.

5.2 Model limitations
There are certain limitations to this logistic regression model. Due to missing cases (34.7 %) the degree of explanation in the model is reduced. One must point out that, the more variables included in the model, the larger the rate of missing cases tends to be (Djurfeldt et al. 2003). This regression model contains seven independent variables and therefore the possibility of missing cases was expected. As mentioned, this reduces the degree of explanation, but, more importantly, it should be mentioned that this has been taken into consideration when interpreting the model and making conclusions. The classification table showed an outcome in 64.4% observed of the total number of predicted cases. This rate is negatively affected, partially, by the missing cases. Furthermore, the generalizability of the model and the study is limited due to the population and sample. This should be considered when reading the conclusions.

5.3 Statistical analysis issues
Issues like heteroscedasticity, autocorrelation and multicollinearity can occur in the statistical analysis and affect the results in a negative way. These issues are considered and dealt with.

To reduce heteroscedasticity the variables are transformed into logarithms. By doing so, the spread of the values of the variables is reduced and, accordingly, heteroscedasticity is reduced.

Change of a value over time is likely to correlate to past values \( (t1 \text{ dependent on } t0) \). This is likely when a lagged version of the y-variable is included in the model as an x-variable, which is the case in the final model \( (R&D \text{ Investments } \( (t-1) \)) \). When this variable is included, autocorrelation is presumable. Autocorrelation of this variable is considered.
Multicollinearity problems are considered in the statistical model. It is likely that macro-factor indicators (the independent variables) are, to some extent, correlated to each other. A correlation matrix was made to examine possible multicollinearity problems among these factors. Complete avoidance of multicollinearity in this case is not reasonable. Some degree of multicollinearity is therefore calculated with. However, correlation rates exceeding 0.8-0.9 indicate problems (Djurfeldt et. al. 2003). Some variables did exceed these correlation rates and were accordingly excluded from the final model. Some variables with lower correlation rates (0.2-0.4) were included in the final model.

6. Conclusions
The main conclusions, discussion and further possible research are presented in this section. The research questions or assumptions of this study are: (1) macro factors do affect R&D investments on a micro-level. But which macro factors do have an affect and to what extent do they affect? A second (2) question or assumption is that macro factors do affect decreases of R&D investments to a greater extent than increases of R&D investments. The purpose was therefore to examine how firms in the industries; Manufacturing of computers, electronics and optics and manufacturing of electrical equipment, have increased or decreased their R&D investments, in conjunction with macro factors during the 2000s. The results rely on the statistical analysis performed through logistic regression. This, together with previous research literature which has been taken into consideration, leads to the conclusions.

Clearly macro factors do affect R&D investments on a micro-level, to some extent. Moreover, the statistical model does not observe 100% of the predicted cases, which of course was not expected. It observes 64.4% of the predicted cases, which could mean that there are additional factors other than the factors tested in this paper that affect R&D investments. As mentioned in the introductory section, macro and micro factors may have an effect on R&D investment decisions, micro factors, such as market competition and managerial factors. Once again, this was expected and accounted for.

The results show that there are differences among the variables, in terms of the effect on R&D investments in a positive or negative way, but it is clear that they do have an effect.
Factors that have a positive relation with R&D investments are; earlier R&D investments, firm size, change in the OMXS 30 stock-market and the long interest rate. The likeliness of earlier investments affecting future investments is significant and an explanatory factor. As regards size, firms unlike micro, small and medium-sized firms, tend to increase R&D investments, which means, the likeliness of a firm increasing their R&D investments is greater if the firm is large. Positive changes in stock-markets can lead to wealthier firms, which in turn increases the possibility of investment in R&D. The long interest rate was to some degree expected to have a positive relation with R&D investments, due the meaning of the rate in itself. Although this is the case, it makes the model better in terms of degree of explanation.

Factors that have a negative relation with R&D investments are; the lending and deposit interest rate that banks use when lending money to firms, periods of crisis (within the scope of this paper 2008 and 2009) and the Swedish Riksbank’s Repo interest rate. When the lending and deposit interest rate increases it becomes more expensive to borrow money from the bank. When firms may finance their R&D investments with a loan, this interest rate can be crucial in making a decision to increase or decrease investments. The natural and theoretical effect of firms financing their entire R&D investments by loans could be substantial reductions in their investments. This raises an interesting question, to what degree does the source of financing affect firms’ R&D investments? Periods of crisis have a significant negative affect on R&D investments. This presumably also has, among other things, to do with potential liquidity problems. It is important to consider in this case is that the period of crisis included in the model are the years 2008 and 2009, which were years of financial crisis. This may strengthen the possibility of liquidity problems among firms during these years. An increase of the repo interest rate has negative effects on R&D investments. The opposite relation is likely as well, when taking into account that the repo interest rate is decreased attempts are made to try to obtain production and investment increases.

Part of the first research question; To what extent do the factors included in the analysis affect R&D investments, is to some degree answered by the odds ratios of each variable. These ratios are presented and can be found in the result and analysis section (5.1).
An interesting reasoning concerning the stock-market and crisis; a stock-market that is in an upward trend has, as mentioned, a positive effect on R&D investments. This could mean that a stock-market in a downward trend has a negative effect on R&D investments and leads to decreases. This could be strengthened with the results concerning the crisis factor. The stock-market does not have to be in a downward trend during the whole crisis year (the variable Crisis (t-1) was transformed to measure 2008 and 2009 as crisis years. The stock-market made a huge downward turn but also an upward turn during parts of 2009), but when there is a crisis, especially a financial crisis as in 2008, the stock-market is highly affected. The point is; since the crisis has a negative effect on R&D investment (according to the statistical model) and the stock-market to some extent follows crisis tendencies, downward trends on the stock-market could also have a negative effect on R&D investments. This is also indicated in previous literature, which shows that a change in factors which can lead to liquidity problems has a negative effect on investments in general (Rafferty and Funk 2007).

However, the main contribution of this paper is within the second (2) research question. The interpreted results, when analysing the logistic regression model, show a tendency that a change in macro factors does to a greater extent, affect decreases in R&D investments than increases in R&D investments. This is due to the indicating values of the observed cases, contrary to the predicted cases in the analysis. The model observed cases of decrease to a greater extent than cases of increase. This research question and conclusion is not a general conclusion among the streams of previous literature, but to pat forward this relationship and reasoning is reasonable. Further reasoning is that, if there is no room to make R&D investments, then investments must decrease. This is inevitable. If there is room to make R&D investments, there is a choice. Either, investments are increased, decreased or unchanged. Thus, firms can chose to increase investments when possible or not to do so.

It is reasonable that making decisions to cut investments is a less complicated decision than making decisions about starting investments. There may be more options when starting up investments and therefore the increasing process of R&D investments could seem to be slower. This shows that there could be differences in the dynamics of R&D investments and lead to the following conclusion; the process of increase and decrease of R&D investment should not be considered as one totally cyclical process, but rather as two different dynamic
processes. Increase and decrease do not follow the same pattern, thus a decrease of R&D investments is a more explicit decision than a decision to increase R&D investments. This conclusion could be of interest to politicians and policy makers when debating and formulating innovation policies. Further research with this reasoning as a basis would be interesting and perhaps strengthen the reasoning of this tendency. This research should preferably use a broader spectrum of firms and industries as study objectives to get more generalizable results.
7. References

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