



# **The largest spender wins? An empirical study of how R&D expenditure drives firm growth in listed Swedish companies.**

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# Preface

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Uppsala, June 2021

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## Table of contents

<b>1. INTRODUCTION.....</b>	<b>3</b>
<b>2. LITERATURE REVIEW.....</b>	<b>7</b>
2.1 FIRM GROWTH .....	7
2.2 RELATIONSHIP BETWEEN R&D EXPENDITURE AND FIRM GROWTH .....	8
2.3 FIRMS WITHOUT R&D EXPENDITURE .....	9
2.4 MEASURING THE IMPACT OF R&D EXPENDITURE IN FIRMS.....	10
2.5 R&D EXPENDITURE AND FIRM SIZE.....	12
2.6 R&D EXPENDITURE AND FIRM AGE.....	12
2.7 R&D EXPENDITURE AND INDUSTRY BELONGING .....	13
<b>3. METHOD AND DATA.....</b>	<b>15</b>
3.1 DATA COLLECTION .....	15
3.2 DATA AND DEFINITION OF VARIABLES .....	15
3.3 EMPIRICAL STRATEGY .....	19
<b>4. RESULTS.....</b>	<b>23</b>
4.1 R&D EXPENDITURE AND SALES GROWTH .....	26
4.2 R&D INTENSITY AND SALES GROWTH.....	27
<b>5. ANALYSIS AND DISCUSSION .....</b>	<b>29</b>
<b>6. ROBUSTNESS TEST .....</b>	<b>32</b>
6.1 R&D EXPENDITURE AND R&D INTENSITY ONE-YEAR LAG .....	37
6.2 R&D EXPENDITURE AND R&D INTENSITY TWO-YEAR LAG .....	38
6.3 ANALYSIS AND DISCUSSION OF ROBUSTNESS TEST.....	39
<b>7. CONCLUSION.....</b>	<b>40</b>
<b>8. LIMITATIONS AND FURTHER RESEARCH.....</b>	<b>42</b>
<b>REFERENCES.....</b>	<b>44</b>
<b>APPENDIX.....</b>	<b>49</b>

# Abstract

The main purpose of this study is to enhance the analysis of the impact of R&D expenditure on firms' growth. This study adopts an OLS regression for a data sample of 46 firms listed on Nasdaq Stockholm for the 2006-2019 period. We present models with R&D expenditure and R&D intensity as the main mechanisms of firm growth, defined as sales growth in this study. Furthermore, firm size, firm age and sector belonging determining the R&D and sales growth relationship are also investigated. We find that R&D intensity has a statistically significant negative impact on firm growth, while R&D expenditure does not show a statistically significant relationship to firm growth. Thus, the results of this paper suggest that devoting a higher proportion of your sales to R&D activities does not translate into firm growth.

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**Keywords:** Innovation, R&D expenditure, R&D Intensity, Firm growth, Sales growth, Firm size, Firm age, Sector belonging

# 1. Introduction

Firm growth is one of the most important areas for economic growth in countries (Machek and Machek, 2014). Furthermore, a crucial component of many organizations and a key factor in developing new competitive advantages is research and development (R&D) (Artz, Norman, Hatfield and Cardinal, 2010). Thus, the existence of R&D is a prerequisite for the development of innovative products and services. R&D also tightly links to firm growth as it is intended to fuel corporate growth (García-Manjón and Romero-Merino, 2012). The relationship between R&D expenditure and firm growth is an area that has been studied for a long period of time. A significant amount of research has been carried out to examine the impact of R&D expenditure on firm growth. Nevertheless, it is not entirely apparent that investment in R&D drives firm growth and ultimately higher real income of countries. Based on a study made by the European Commission (2014), despite an increase of 2,6% in R&D investments in Europe, sales decreased by 1,9% and operating profits decreased by 6,6%. However, interest in R&D expenditure has continued to increase in the business community and across countries (Vanderpal, 2015). In China, R&D expenditure has increased significantly throughout the years, in 2015 accounting for 21% of global R&D expenditure, after a share of only 5% in 2000 (European Commission, 2020). Similarly, the U.S firms spent \$441 billion on R&D in 2018, a 10,2% increase from 2017 (Wolfe, 2020). The large sums invested in R&D every year raise the question whether it is being translated into firm growth?

Some researchers have found a positive impact of R&D on firm growth (Choi and Williams, 2014; Geroski and Machin, 1992; Yasuda, 2005), while others suggest that there is no significant impact (Booltink and Saka-Helmhout, 2018, Almus and Nerlinger, 1999; Bottazzi et al., 2001; Lööf and Heshmati, 2006), and some even find a negative impact (Brouwer et al., 1993; Freel and Robson, 2004). In this sense, it is not entirely evident that R&D and new technologies determine an increase in corporate value, leading to failure in regard to business expectations (Vanderpal, 2015). The inconclusiveness of these studies motivates the paper's question: What is the impact of R&D expenditure on firm growth?

R&D activity is often associated with significant costs and whether firms will get a profitable return on their investments is not guaranteed. As the search for new technologies and processes is unpredictable, this makes the R&D process highly uncertain (Montmartin and Massard, 2014). Nordhaus (1969) maintains that when investing in R&D an opportunity cost arises on

resources that could be used for other purposes. Furthermore, as R&D expenditure increases the time for the full benefits of the investments in R&D to materialize also increases. Thus, there is a time gap between the point of R&D expenditure and the cost reductions and benefits of R&D that firms experience. This is why the existing empirical findings such as in the works of Das and Mukherjee (2019), Levin, Klevorick, Nelson and Winter (1997), Samimi and Alerasoul (2009), and Bozkurt (2015) reveal that R&D expenditure does not necessarily improve the real income of the researched countries, nevertheless in some cases, it positively impacts firm growth. Moreover, the impact of R&D expenditure on firm growth may differ depending on the sector, firm size and firm age under consideration (Spescha, 2019). Together with the increasing importance for firms to invest in R&D, it therefore becomes highly important to investigate the impact of R&D expenditure on firm growth.

The findings on R&D expenditure and its relationship to firm growth presents different results. There is a wide array of studies that point toward an increase in R&D activity in firms and that highlight the importance of R&D to firm growth (Akcali and Sismanoglu, 2015; Pandit, Wasley and Zach, 2011). However, previous studies maintain that R&D expenditure does not have a significant effect on firm growth (Booltink and Saka-Helmhout, 2018, Almus and Nerlinger, 1999; Bottazzi et al., 2001; Lööf and Heshmati, 2006). Furthermore, the impact of R&D on firm growth is highly context dependent, i.e. industry, research capabilities, knowledge intensity, etc. (Brinckmann and Rosenbusch, 2011). We see that specific industries such as pharmaceuticals, IT, manufacturing and telecom experience a higher impact of R&D expenditure on firm growth (Nivoix and Nguyen, 2012; Öztürk and Zeren, 2015; Garcia-Manjon and Romero-Merino, 2012). Hence, choosing to look at certain industries and not country wide is most likely due to previous findings indicating that R&D expenditures and its impact is tightly tied to industry specific factors and its structure (Chung, Eum and Lee, 2019). While the approach used by previous scholars provides clear data for specific industries it falls short in conveying a broader understanding of how R&D expenditure affects firm growth when looking beyond a certain industry. In this sense, examining the impact of R&D expenditure on firm growth in different industries is a viable option. Thus, the purpose of this study is not to isolate firms in specific industries, rather it takes a holistic approach on the impact of R&D expenditure.

To investigate the impact of R&D expenditure on firms' sales growth, this paper utilizes an ordinary least squares (OLS) regression on a data sample of companies listed on the Stockholm Stock Exchange (Nasdaq Stockholm) between the years 2006-2019. In addition, we develop regression models with R&D intensity as the independent variable. This, in order to examine whether there exist differences in the impact on firms' sales growth when measuring R&D expenditure in absolute numbers or as a ratio of sales. Furthermore, the variables firm size, firm age and sector belonging are included in the regression models to investigate their impact on the R&D-growth relationship. Our findings imply that there is a significant negative impact of R&D intensity on firms' sales growth and a small positive significant impact of firm size on the R&D intensity-growth relationship. However, R&D expenditure does not show any significance to sales growth. Thus, the results of this paper indicate that allocating a higher proportion of your sales to R&D activities does not translate into firm growth.

The contribution of this study is to provide a better understanding of the impact R&D expenditure and R&D intensity have on firm growth. It generates new insights emerging from the Swedish stock market where the R&D to firm growth relationship is currently scarcely mapped. In Sweden, R&D expenditure increased with 4,6% from 2017 to 2018 and 3,9% from 2018 to 2019 and in 2019 R&D intensity was at its highest in over 10 years. Furthermore, Sweden exceeded the overall EU target in Europe 2020 strategy of R&D intensity of 3% (SCB, 2020). In this sense, the Swedish market becomes of high interest to study the impact of R&D expenditure and R&D intensity on firms' sales growth. Furthermore, while this paper builds particularly on the findings of Spescha (2019) and Chung et al. (2019) this study includes all firms, regardless of industry and sector belonging, listed on Nasdaq Stockholm when examining the impact of R&D expenditure on firm growth. We examine R&D expenditure which entails basic research, applied research and development costs of new products. The metric is included to provide a broad picture of the impact of R&D on firm growth by including different sources of the R&D efforts undertaken by the firms in our data sample. In addition, we examine the impact of R&D intensity on firms' sales growth to investigate whether the impact changes when looking at R&D expenditure as a percentage of sales. Thus, this study will provide a wider scope of organizations with valuable insights regarding whether it is worth investing in R&D and if R&D, measured as R&D expenditure and R&D intensity, gets translated into firm growth, leading to more efficient management of R&D in organizations.

The remainder of this paper is organized as follows. Section 2 reviews the existing literature on firm growth, R&D expenditure and R&D intensity, including the relationship between R&D expenditure and firm size, firm age and sector belonging. Section 3 presents the method, data collection, data and variable definition, and empirical strategy. Section 4 includes the main empirical results. Section 5 discusses and analyzes the main results. Section 6 presents the robustness test and the results. Section 7 presents concluding remarks and finally the limitations and further research suggestions are included in Section 8.

## 2. Literature Review

### 2.1 Firm growth

Firm growth is a broad concept (García-Manjón and Romero-Merino, 2012), thus theoretical contributions can be divided into two approaches: The deterministic one and the stochastic one (Oliveira and Fortunato, 2006). The deterministic approach argues that differences in a firm's growth rate depend on measurable company and industry-specific aspects. Regarding which characteristic carries the most weight, researchers have provided mixed answers. Freeman and Hannan (1977) state that the environment, rather than internal factors, matters the most, whereas Baum and Locke (2004) argue that internal factors are the essential ones. The stochastic approach on the other hand maintains that “[...] in a world without ex ante differences in profits, seize, and power market across firms [...]” (García-Manjón and Romero-Merino, 2012; p. 1085) growth rates should be predicted independently of firm size and past growth history.

Regarding how to measure firm growth, researchers adopt one of two approaches. One approach is the usage of multiple indicators, highly recommended by some (Davidsson, 1991; Delmar, 1997), the other one is the single variable approach, preferred by others (Hoy et al. 1992; Freeman, Nystrom, Weinzimmer, 1998). Concentrating on the single variable approach sales data is preferred over metrics such as market value, number of employees, value of production etc. (Hoy et al., 1992). This goes well in hand with more recent findings, naming sales as the best metric for firm growth since e.g., “[...] the number of products or services sold in the market is the most important determinant of firm size.” (Specsha, 2019, p. 159).

In summary, the research on firm growth has evolved immensely over the years. The area is divided into deterministic and the stochastic approach, separated by their belief in what drives firm growth. Lastly, and connecting firm growth to R&D, it has been found that firm growth is “[...] the gateway to the introduction of innovations and technical change” (García-Manjón and Romero-Merino, 2012; p. 1084). Therefore, the next section will dive deeper into where current literature stands on measuring the impact of R&D expenditure.

## 2.2 Relationship between R&D expenditure and firm growth

On a business level it is expected that “[...] the creation of knowledge will influence the development of the firm in terms of sales growth, profitability, or employment creation” (García-Manjón and Romero-Merino, 2012, p. 1085). In short, a positive relation between R&D expenditure and firm growth is deemed probable. Beyond absolute numbers such as R&D expenditure, a frequently examined metric used to map R&D activities within firms is R&D intensity (Hall and Bagchi-Sen, 2002; Morbey and Reithner, 1990; Schoenecker and Swanson, 2002; Spescha, 2019). The ratio is calculated as  $R\&D\ intensity = \frac{R\&D\ expenditure}{Sales}$ .

The statement that a positive relationship between R&D expenditures and firm growth should occur has historically indeed been observed: When analyzing 54 chemical companies over 15 years Brenner and Rushton (1989) found that high growth entities were more successful in their R&D spending and invested much more consistently in R&D than companies showing weak growth. Adding to this Morbery and Reithner (1990) studied over 100 US companies for the period 1978-1987, observing how R&D expenditure had driven the most essential of firm growth metrics, sales, within all companies. More recently, in the Japanese pharmaceutical industry, Nivoix and Nguyen (2012) found a positive link between R&D intensity and eminent firm growth.

Furthermore, mapping specific industries is essential when discussing R&D expenditure and firm growth as it has been determined to be a highly influential factor (Brynjolfsson and Yang, 1996). Examining a particular R&D intensive setting, the tech industry, one could reason that the knowledge packed environment would showcase a strong correlation between R&D expenditure and firm growth. Such thoughts are confirmed by several researchers (Chan, Kensinger and Martin, 1990; Zantout and Tsetsekos, 1994) while low-tech industry firms instead observed a negative relationship (Chen, Shieh and Yu, 2010). What several of these researchers seem to agree upon though is that a considerable time span is needed for companies to convert resources devoted to R&D into actual firm growth (García-Manjón and Romero-Merino, 2012). This is exemplified by the works of Huang and Yang (2005) who studied the Taiwanese electronic industry, finding that R&D expenditure affected firm growth, measured as employment growth.

Looking at cross-national studies the connection between R&D expenditure and firm growth becomes more complex. García-Manjón and Romero-Merino (2012) investigated 754

companies across 18 European countries during the years 2003-2007 and provided empirical evidence that R&D spending could indeed prove vital for some businesses and sectors. The authors did however also underline that R&D spending is not by any means a guarantee for firm growth as the effect was highly dependent on what type of industry the R&D spending took place in. Linking into this, the findings of Bausch, Brinckmann and Rosenbusch (2011) highlight that the relationship is indeed highly context dependent, while still stating that businesses “[...] can benefit even more if they develop, communicate, and embrace an innovation orientation” into their company culture (Bausch et al. 2011, 452). Moreover, in some studies the R&D expenditure to firm growth relationships has even proved to be negative. Examining US pharmaceutical firms between 1950-2009, Demirel and Mazzucato (2012) found a weak and in some situations even a negative relationship between R&D and firm performance. This negative effect was primarily observed within larger pharmaceutical firms, something that the authors speculated could result from the low R&D productivity, hampering in particular the larger firms.

Summarizing, previous findings in academia underline a positive relationship between R&D expenditure and firm growth. In the 1990s more focus turned to the differences between industries, as researchers found that the relationship was context dependent. The articles published in the 2010s convey an increasingly complex connection between R&D expenditure and firm growth. Lastly, we observed how firm size could play a role in how well companies capitalized from their R&D expenditure.

## 2.3 Firms without R&D expenditure

While there is a common understanding of the significance for firms to invest in R&D to survive, little attention has been devoted to firms that decide not to engage in R&D activities or who do so moderately. Recent years show a strong indication of a rise in policies that aim to advocate R&D behavior of small and young firms (Audretsch, Segarra and Teruel, 2014). According to the authors there is a large portion of small young firms that decide not to invest in R&D to avoid the inherent risks that R&D activities entail. Even though R&D activities pose risks for all firms regardless of their size and age, young small firms may experience even higher obstacles. These barriers involve e.g., lack of financial resources, lack of absorptive capacity (small young firms may face difficulties in attracting more skilled employees and thus

experience difficulties in handling complexity), and lack of the granting of benefits from R&D activities, as this requires strategies to patents, e.g., secrecy and trademarks, which all require a level of scale that SMEs may not have (*ibid.*).

Furthermore, although R&D may positively impact sales or reduce costs, the evidence is not conclusive. Geroski and Machin (1992), highlight relatively significant and persistent differences in the profits of innovators and non-innovators. However, in the short-term innovators may be related with lower profits as the benefits of investing in R&D usually manifest themselves in increased profits after a few years (Heunks, 1998). Furthermore, to gain the long-term profits derived from R&D activity, firms must be able to exert e.g., property rights, employ secrecy or first mover advantages (Dosi and Teece, 1998). Taking these into consideration, firms may not view positively on becoming R&D intensive firms and instead adopt a more conservative strategy without having to invest in R&D. In this sense, firms may adopt a quality strategy and develop long-term relationships by increasing customer satisfaction.

In summary, while there is unity involving the necessity of the policies that promote R&D to increase the number of innovation-driven firms, it is less clear why some firms decide to invest moderately. The initial ability for a firm to enter and settle down in the market and the initial R&D nature of a firm all influence the firm's behavior. In a sense, this increases the significance of policy makers to be more aware of the firm and sectoral characteristics that may hinder these firms to become R&D intensive firms. Moreover, other factors that may influence firms' R&D behavior such as levels of volatility and uncertainty, and stability of demand must also be taken into consideration (Audretsch et al. 2014).

## 2.4 Measuring the impact of R&D expenditure in firms

Lazarotti, Manzini and Mari (2011) argue that R&D includes resources and activities such as applied research, basic research, development, and some support activities like technology intelligence. In R&D resources they have identified people, tangible resources, and intangible resources. Furthermore, progress through R&D is increasingly viewed as a major contributor to growth in firms (Inekwe, 2014). Salimi and Rezaei (2018) maintain that R&D activities are key drivers of the competitiveness, growth, and productivity of firms. However, while R&D

activities are becoming increasingly important for the performance of firms, the main concern for firms with R&D involves measuring R&D performance and to capture the impact R&D has over firms (Bilderbeek, 1999; Moncada-Paternò-Castello, Ciupagea, Smith, Tübke and Tubbs, 2010; Lazzarotti et al., 2011; Schwartz, 2011). Moreover, because R&D activities are highly complex and require a variety of technical and scientific knowledge, this makes them costly and risky. In turn, this adds to why measuring R&D performance has become a critical issue for many firms (Tidd, Bessant and Pavitt, 2005). Many attempts have been made to develop metrics to quantify the success or failure of R&D expenditure in firms and the effects on firm performance. Consequently, a wide range of metrics have been created, from financial measures such as R&D expenditure as a percent of sales (which as previously stated is known as R&D intensity) (Andrew et al., 2008; Hauser, 1996), to more complex measures such as strategic alignment (Roussel, Saad and Erickson, 1991). Moreover, a study made by the European Industrial Research Management Association (EIRMA) lists over 250 potential R&D metrics (EIRMA, 2004). Nevertheless, influential factors of the R&D measurement such as organizational level, type of R&D, type of industry, and organizational size add to the complexity of capturing the effectiveness of R&D expenditure and its impact on firm performance (Kerssens van Drongelen and Cooke, 1997; Bilderbeek, 1999; Salimi and Rezaei, 2018). Furthermore, differences in R&D investment, particularly business R&D spending, between countries reflects differences in knowledge intensity of sectors, industrial structures and research capabilities (European Commission, 2019). Thus, when studying the impact R&D has on firm growth it becomes significant to choose R&D measures that capture multiple industry characteristics.

In summary, previous literature holds that progress through R&D contributes to the growth, competitiveness, and productivity of firms (Inekwe, 2014; Salimi and Rezaei, 2018). In turn, the increasing importance of R&D for firm performance has created the need for metrics that capture and measure the impact of R&D on firm growth. However, influential factors such as type of R&D, research capabilities, knowledge intensity, and industry characteristics add to the complexity of choosing the appropriate R&D measures that capture the impact R&D expenditure has on firm growth.

Having noted how firm size, firm age and different economic sectors might affect the R&D expenditure to firm growth relation, the remainder of this literature review will present previous findings on their impact.

## 2.5 R&D expenditure and firm size

Existing research points out several reasons as to why large firms could have more benefits over small firms in the R&D process and experience a larger impact on their sales growth. Demirel and Mazzucato's (2012) results suggest that for small firms R&D expenditure does not appear to be a strong driver of firm growth. Their findings also imply this for small patentee firms that fail to achieve higher firm growth through R&D expenditure unless they patent persistently for a minimum of five consecutive years. Thus, what can be drawn from this is that the key to R&D generated growth for small firms is the persistence in R&D expenditure. Furthermore, they found that for large firms, R&D expenditure resulted in increased firm growth. Nevertheless, this positive relationship does not apply for large non-patentee firms in which R&D efforts fail to generate sales growth (*ibid.*).

Nivoix and Nguyen (2012) point to why large firms should have considerable benefits over small firms regarding their R&D activities and experience a larger impact on top line growth. The authors argue that firm size contributes to a higher R&D intensity and therefore R&D expenditure, drawing from the argument that larger firms have better access to product diversification as well as better opportunities in mitigating risks (Myers, 1977). Furthermore, compared to small firms, larger entities have the advantage of collecting resources to drive R&D activities. Thus, although small firms can have good projects and innovative ideas, they have less of an advantage due to resource restraints that hinder them in the R&D process.

In summary, we can find that firm size has an impact on the relationship between R&D expenditure and firm growth. While R&D expenditure does not seem to be a significant driver of firm growth in small firms, evidence indicating the opposite has been found for larger firms.

## 2.6 R&D expenditure and firm age

The idea that younger firms consist of people who through a stroke of genius instinct manage to boost sales growth is challenged by Schumpeter (1950). The author portrays knowledge as something that is derived from a mere deductible approach and that the passionate entrepreneur would in the long run be chance-less against the resources of the R&D departments of older, traditional, companies (*ibid.*). However, in contrast to Schumpeter's view Spescha (2019) presents findings indicating that R&D is partly a trial-and-error process. Abernathy and

Utterback (1978) build on the work of Schumpeter, stating that young firms often must account for market needs that are vague and far from clear. It could then be argued that the same challenge could certainly be faced by older companies, nevertheless older firms might then have more resources to overcome them. The idea that older firms would be better equipped to achieve more efficient growth from their R&D expenditure is confirmed by Coad and Rao (2010), arguing that R&D departments will learn over time how to operate in the most efficient manner. This plays well into the findings of Doraszelski (2003) who affirms that the previous R&D activities of a company enhances the productivity of the firm's present R&D engagements.

There are several studies cementing the indications that firm age does provide a better chance of R&D expenditure generating a favourable growth rate. Stam and Wennerberg (2009) find that R&D does not boost growth rates of young low-tech start-ups, where growth instead was dependent on the ambitions of the firm's founding people. Nunes, Gonçalves and Serrasqueiro (2013) maintain that R&D intensity has higher importance for older and larger SMEs rather than for their younger and smaller competitors.

Summarizing the age variable, current academia is arguing that more mature firms should achieve higher growth from their R&D expenditure than their younger counterparts. This in part originates from the fact that a firm's age affects which sort of challenges it faces once it approaches R&D activities and, more specifically, how to allocate their R&D expenditures. The set of tools that the companies have at their disposal to meet said challenges also varies with firm age (e.g., older firms often having more resources). The evidence also indicates that older firms might be more heavily reliant on R&D as they mature compared to younger entities, which could be linked to why they are more successful.

## 2.7 R&D expenditure and industry belonging

Research on the relationship between R&D expenditure and sales growth in specific industries and sectors show various results. Studying the manufacturing industry in Turkey, the findings of Öztürk and Zeren (2015) imply that R&D expenditure has a positive effect on sales growth. We can also find quicker sales growth in R&D firms in the steel and petroleum industries (Mansfield, 1962). Likewise, this positive effect on R&D expenditure on firms' sales growth is also found by Del Monte and Papagni (2003) who studied a sample of Italian manufacturing

firms. However, their results show that the impact is more significant in traditional firms than in technology-based firms. This is explained by the high competitiveness with respect to foreign firms among firms in the traditional industries. Nevertheless, the authors argue that where competitiveness is not particularly based on research, in sectors with a high degree of R&D no major differences are found between firms that do research and those that do not. In contrast to this, Garcia-Manjon and Romero-Merino (2012) find that compared to low-technology industries and less-incentive-knowledge services only high-technology businesses obtain clear benefits from their R&D expenditure.

Nivoix and Nguyen (2012) argue that while it is true that R&D tends to be associated with increasing sales, this might not always be the case as the overall conditions in a specific industry may blunt the relationship between R&D expenditure and sales growth. Research findings from the pharmaceutical industry in Japan point toward a non-persistent growth in sales in pharmaceutical companies compared to other R&D active firms. Hence, in contrast to pharmaceutical firms, an increase in sales in a given year tends to be followed by an increase in the following year and vice versa for firms in other industries. This is because the benefits expected from R&D expenditure for pharmaceutical firms are likely to take more time to impact sales growth (Nivoix and Nguyen, 2012).

In sum, the effect of R&D expenditure on firm growth is dependent on within which industry the expenditures are taking place. The competitive constellation of the industry and sector is another factor affecting how well entities are capitalizing on their R&D investments. Lastly, the pace of which companies can expect to grow from their R&D investments differs across industries.

## 3. Method and data

### 3.1 Data collection

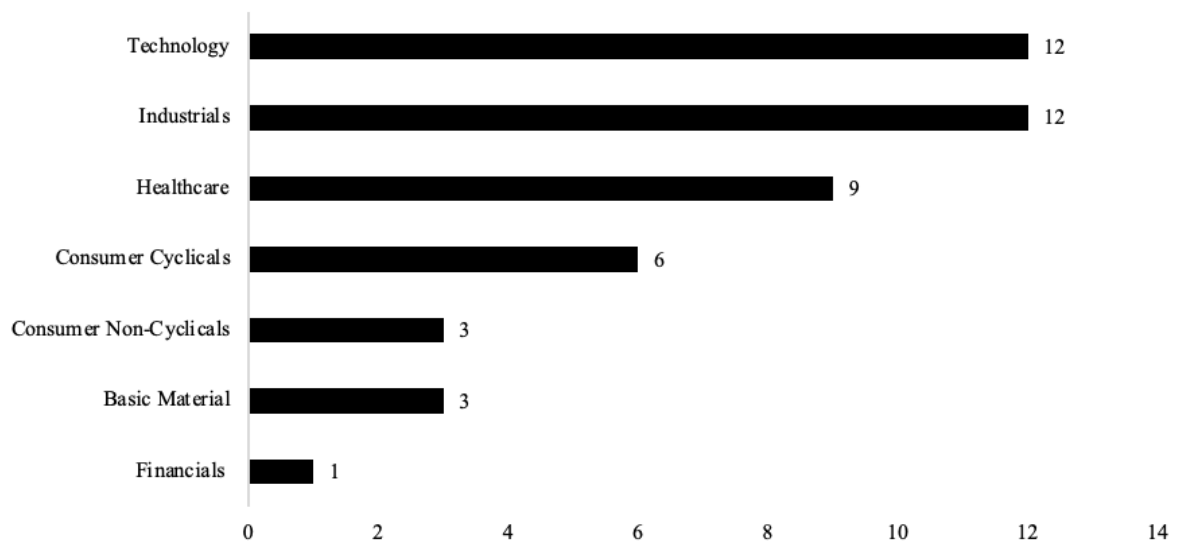
The companies and the data related to them; R&D expenditure, R&D intensity, sales, market value and sector belonging was gathered using the EIKON database - distributed by Thomson and Reuters. The only exception to this was firm age which was retrieved from Business Retriever. Gathering our sample, we used the following approach: First, we filtered for all companies that had been publicly traded on the Stockholm Stock Exchange (Nasdaq Stockholm) small, mid or large cap between the years 2006-2019. Since all companies had to remain listed throughout the entire time span, excitors and joiners were excluded. Excitors and joiners are referring to companies that are either taken off the stock exchange by going private (excitors) or companies that have been through an Initial Public Offering somewhere during our time span (joiners). Second, we retrieved the relevant data for all companies (sales, R&D expenditure, R&D intensity, firm age, firm size and sector belonging) using the EIKON database. R&D intensity was calculated from the R&D expenditure and sales data. We chose to only include firms that had accounted R&D expenditure in the entire observed timespan in this study. This is an approach that is favored in previous research (Spescha, 2019) and including zero values would most likely reduce the power of the model (Pandit et al., 2011). Third, we did one final sorting as a small number of firms showed two anomalies: Some had negative sales for several of the years while some showed negative R&D expenditure numbers. We strived to verify this against the companies' own annual reports but those firms that we were unable to do so for were excluded. This was done to ensure that the sample would only include controlled entities and data. After the above-mentioned steps were undertaken this resulted in a reduction in sample size from 160 to 46 firms.

### 3.2 Data and definition of variables

In this section Figure 1 shows the distribution of the 46 firms across small, mid, and large cap and in Figure 2 the sector distribution is given. Figure 3 provides an overview of the firm age of the included entities.

In March 2021, 832 companies were listed on Nasdaq Stockholm of which 385 were traded in the main market, with an additional 447 listed on Nasdaq First North and Nasdaq First North

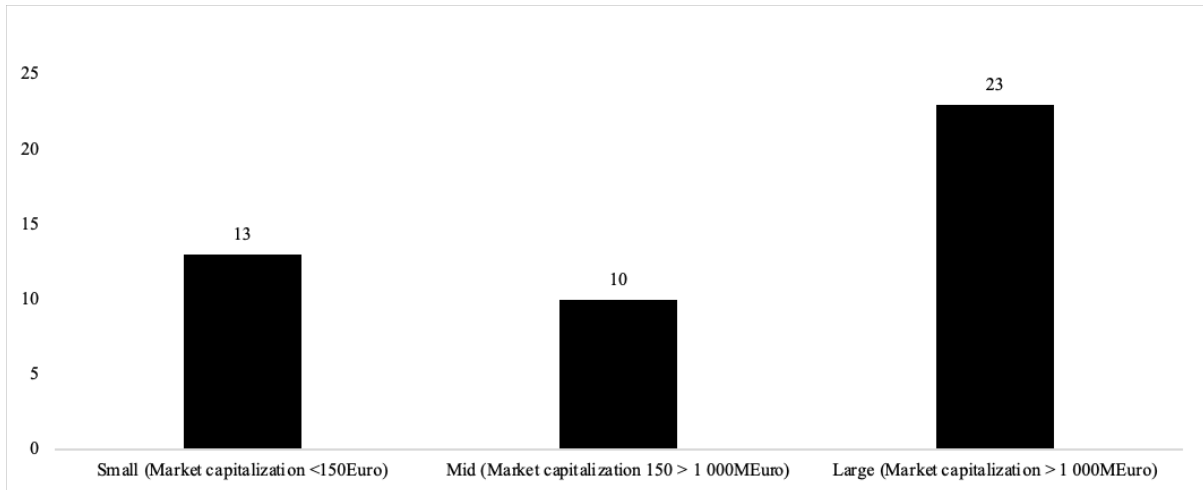
Premier (Nasdaq, 2021). All companies were sorted to a respective sector belonging in accordance with Thomson Reuters Business Classification (TRBC). Below is our sample distribution per economic sector shown. The data is dominated by firms within the Technology and Industrial sectors. Financials on the other hand include only one firm, with Consumer Non-Cyclicals and Basic Material having the second lowest numbers with three firms present in each sector.



**Figure 1. Sector Distribution.**

*Notes: Distribution across Economic Sectors for all the 46 included firms, classification in accordance with (TRBC).*

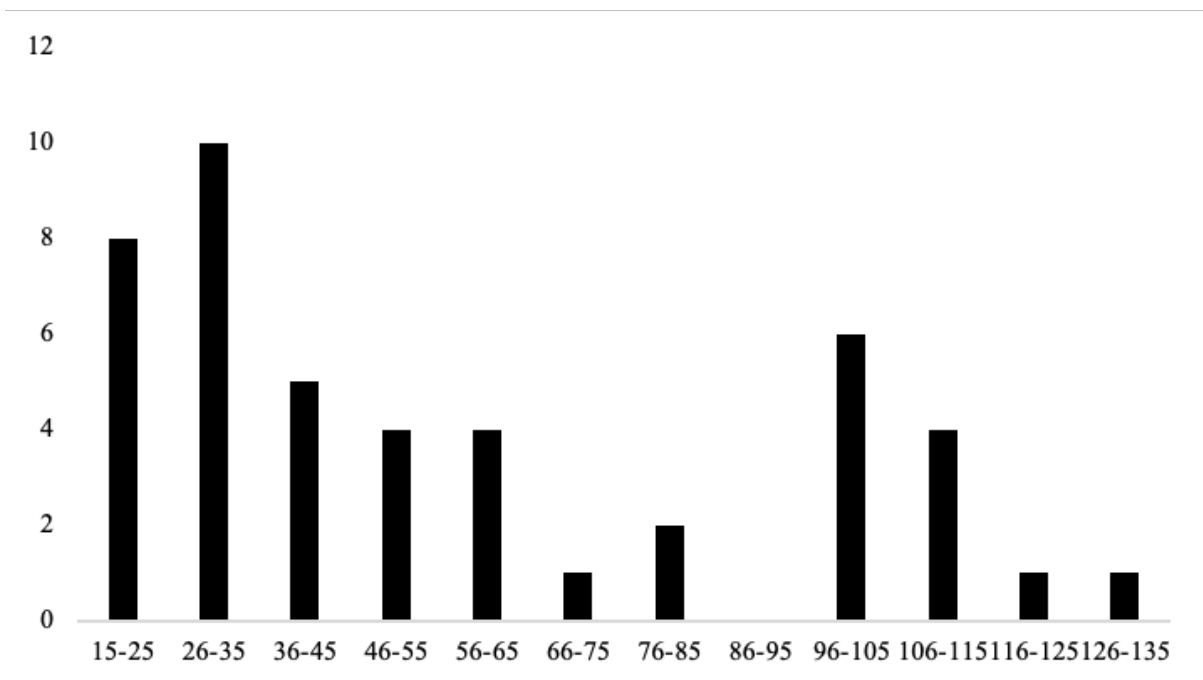
Most of the firms in our data place into the large cap marketplace, mid cap being the marketplace with the least number of firms, seen below in Figure 2. The distribution of our sample potentially originates from the increased likelihood of larger companies being more prone to allocate money to R&D expenditures. Finally, the market cap belonging is shown as per 2019-12-31.



**Figure 2. Marketplace distribution.**

*Notes: Distribution of the included firms across the Nasdaq Stockholm small, mid, and large cap, in accordance with market value as per 2019-12-31.*

Moreover, Figure 3 illustrates the age intervals (x-axis) of the included companies, expressed in years. Our sample is dominated by the age span 26-35 years old, with companies aged 15-25 years constituting the second largest group. The least number of companies, while still being represented, is found in the age intervals 66-75, 116-125 and 126-135 years old.



**Figure 3. Firm age interval across the included companies.**

*Notes: Distribution of the included firms' age interval as per 2019-12-31.*

The dependent variable used in this study is sales growth ( $s_{i,t} - s_{i,t-1}$ ). This paper defines firm growth as sales growth, here calculated as the following: Growth in gross sales and other operating revenue subtracted for discounts, returns and allowances. Thus, following previous research we have used sales growth as a metric for firm growth (Hoy et al., 1992) who found that it was the most suitable metric to describe growth. Furthermore, we are using two independent variables, R&D expenditure ( $(r_{i,t})_{t-3}$ ) and R&D intensity ( $r_{i,t-3}/s_{i,t}$ ), in separate regression models in order to investigate the R&D-growth relationship from different perspectives. The R&D expenditure and R&D intensity variables used in the empirical analysis always refers to the three years preceding the firms' first sales year. Hence, when the dependent variable refers to the sales growth between the years 2009-2019, the independent variables R&D expenditure and R&D intensity refers to the yearly spending between the years 2006-2016. Examining previous literature, research effort takes about 2-3 years to materialize in innovation results (Hall, Mairesse, and Mohnen, 2010), in this sense the chosen lag structure is adequate.

In addition to the independent variables, three control variables are used in this study to test the relationship between R&D expenditure and sales growth. The three control variables are found below:

(I) Firm age ( $a_{i,t}$ ), defined as the last year of our sample interval, 2019, deducted by the date the firm was founded. This means that some firms can seem younger than our included time span. For example, as we can see in Table 3, the youngest firm was merely four years old, whereas our time span for the firm age variable is between 2009-2019. However, this only implies that the firm was four years old during our first year of measuring firm age (2009).

(II) Firm size ( $m_{i,t}$ ), defined as the firm's market value, meaning the combined value of the traded shares.

(III) Sector belonging ( $sb$ ), being required to use dummy variables here we have chosen to divide the companies into sectors, rather than industries since Thomson Reuters Business Classification (TRBC) contains over 150 industries, but only 13 economic sectors. Thus, this is a way of rendering the regression more manageable in terms of the number of dummy variables needed to be included. Our data sample contained seven of the 13 sectors. In the

regression we used industrials, which along with technology represented the sector with the highest occurrence in our sample, leaving us with data output for six dummy variables.

### 3.3 Empirical strategy

To investigate the impact of R&D expenditure on firm growth we utilize an Ordinary Least Squares (OLS) regression using SPSS. Using OLS regression is favored by articles seeking to study the relationship between R&D expenditure and firm growth (García-Manjón and Romero-Merino, 2012; Spescha, 2019). R&D expenditures here mean transactions listed in accordance with International Reporting Standards (IFRS) and classified as research activities under International Accounting Standard (IAS) 38. Moreover, panel data of the firms under consideration was used to investigate the R&D-firm growth relationship. In this sense, the data sample consists of the same firms for the period 2006-2019 to achieve consistency. We measured the R&D expenditure of a firm at time  $t$  to predict the firm's growth at time  $t+3$  and used values for the independent variable from 2006 to 2016. In this sense, the dependent variable together with the other variables firm size, firm age and sector belonging runs from 2009 to 2019.

Table 1 first presents an overview of the descriptive statistics for the variables used in the empirical estimations. To obtain more naturally distributed variables where appropriate all variables except for firm size, expressed as market value, have been logged using the base ten. The reason for not logging the market value variable was to adjust for high VIF (Variance Inflation Factor) values; a logged market value showed significantly high correlation values with R&D expenditure. This raised a concern of multicollinearity in the model. Thus, not logging the market value was a way to adjust for this.

**Table 1. Descriptive statistics of variable**

Variables	Description	Obs	Mean	Median	Std Dev	Min	Max
$S_{i,t} - S_{i,t-1}$	Logarithm sales growth between period 't-1' and 't'	506	0,02	0,02	0,15	-1,05	1,32
$r_{i,t-3}$	Logarithm of R&D Expenditures, lagged 3 years, noted in thousands of SEK	506	5,21	5,19	0,90	3,20	7,56
$r_{i,t-3}/s_{i,t}$	Logarithm of R&D Intensity, lagged 3 years, noted in thousands of SEK	506	-1,35	-1,42	0,62	-2,83	1,47
$a_{i,t}$	Logarithm of firm age, noted in number of years	506	1,60	1,54	0,31	0,70	2,13
$m_{i,t}$	Firm market value, noted in thousands of SEK	506	58 361 031,11	5 280 500,00	114 029 798,20	24 580,00	871 892 300,00

*Notes: Descriptive data output for the included variables. Showcased metrics entail numbers of observations (Obs), the mean, median, standard deviation, minimum value and maximum value of the respective variable.*

The interest in this paper lies in the impact of R&D expenditure and R&D intensity on firm growth. Moreover, because we are interested in the R&D-growth relationship we take into consideration the fact that the factors firm size, firm age and sector belonging may influence it. Hence, we need to directly include the firm size, firm age and sector belonging variables into the estimation equation. Building on the empirical strategy of Spescha (2019), to test whether R&D expenditure and R&D intensity positively affects firm growth in terms of sales growth of firms, this study includes eight models that we build our analysis on.

The first model examines the relationship between solely R&D expenditure and sales growth, formulating Equation (1):

$$s_{i,t} - s_{i,t-1} = \alpha + \beta_1 M_{it} + \beta_2 r_{i,t-3} + e \quad (1)$$

Because  $(r_{i,t-3})$  is naturally higher for large firms,  $(m_{i,t})$  explicitly controls for potential differences in firm size in the first regression model. The second model examines the R&D expenditure and sales growth relationship adding an interaction term with firm size (=market value) and the sector belonging control variable. Furthermore, the third model examines the R&D and sales growth relationship adding an interaction term with firm age and the sector belonging control variable. Lastly, the fourth model examines the R&D and sales growth relationship with all the variables together, formulating the full equation, Equation (4):

$$s_{i,t} - s_{i,t-1} = \alpha + \beta_1 M_{it} + \beta_2 r_{i,t-3} + r_{i,t-3} \times a_{i,t} + \beta_3 a_{i,t} + r_{i,t-3} \times m_{i,t} + s_b + e \quad (4)$$

In addition, we have also formulated models with R&D intensity as a metric for R&D activity. This has been done to investigate whether there exist differences in the impact on firms' sales growth when measuring R&D expenditure in absolute numbers or as a ratio of sales. The R&D intensity coefficient changes the interpretation of the other coefficients, as we now look at the association between the sales growth rate and the R&D intensity. Like argued by Spescha (2019), this specification is more robust to concerns of multicollinearity, as the R&D intensity variable varies much less with the sales variable than does the R&D expenditure variable. Thus, it is necessary to investigate the impact of R&D intensity on sales growth. The models with R&D intensity have been formulated in the same manner as our first four models, replacing R&D expenditure for R&D intensity. Replacing R&D expenditure ( $r_{i,t-3}$ ) with R&D intensity ( $r_{i,t-3}/s_{i,t}$ ) in model 5, Equation (5) is formed in the same manner as Equation (1):

$$s_{i,t} - s_{i,t-1} = \alpha + \beta_1 M_{it} + \beta_1 (r_{i,t-3}/s_{i,t}) + e \quad (5)$$

The sixth model examines the R&D intensity and sales growth relationship adding an interaction term with firm size (=market value) and the sector belonging control variable. Furthermore, the seventh model examines the R&D intensity and sales growth relationship adding an interaction term with firm age and the sector belonging control variable. Lastly, Equation (8) formulates the full regression model in with R&D intensity as the independent variable:

$$s_{i,t} - s_{i,t-1} = \alpha + \beta_1 M_{it} + \beta_1 (r_{i,t-3}/s_{i,t}) + (r_{i,t-3}/s_{i,t}) \times a_{i,t} + \beta_3 a_{i,t} + (r_{i,t-3}/s_{i,t}) \times m_{i,t} + s_b + e \quad (8)$$

The dependent variable ( $s_{i,t}-s_{i,t-1}$ ) stands for the logarithmic sales growth. Our first independent variable ( $r_{i,t-3}$ ) stands for the logarithm of R&D expenditures, lagged three years. Moreover, our second independent variable ( $r_{i,t-3}/s_{i,t}$ ), stands for the logarithm of R&D intensity, lagged three years. Like R&D expenditure, R&D intensity is highly skewed, the variables are logged using the base 10. Using a lagged variable here is a favored approach, given that there is a lag between when a company decides to make an R&D investment and when said investment starts generating sales growth (Chung et al. 2019). Selecting three years to be the appropriate lag is based on the article by Huang and Yang (2005). In turn, this results in R&D expenditure and R&D intensity data being recorded from 2006-2016 while the dependent variable sales growth and the rest of the variables are for the years 2009-2019. Furthermore, because ( $r_{i,t-3}$ ) is

naturally higher for large firms the firm size variable ( $m_{i,t}$ ) explicitly controls for potential differences in firm size. ( $A_{i,t}$ ) stands for the logarithm of firm age. ( $M_{i,t}$ ) stands for the firm market value (=firm size). To test whether the impact of R&D on firm growth varies depending on firm size, using market value to define firm size provides a concise way to assess the impact of firm size on the R&D-growth relationship. Furthermore, an interaction term between R&D expenditure and age, ( $r_{i,t-3} \times a_{i,t}$ ), and R&D expenditure and market value ( $r_{i,t-3} \times m_{i,t}$ ) have been formulated. This is because we want to examine if the effect of our independent variable R&D expenditure on our dependent variable sales growth changes depending on the age and firm size variables. This builds on the methodology utilized by Spescha (2019) who studied the interactive relationship of firm age and size with the R&D and firm growth relationship. Adding interaction terms allow for a broader understanding of the relationship between R&D expenditure and sales growth. In this sense, the impact of R&D expenditure on sales growth is not limited solely to the amount of R&D expenditure, but it is also represented by the variables age and size which are multiplied with R&D expenditure. Lastly, *sb* stands for sector belonging and this ordinal variable is converted into a data output of six dummy variables. In total they develop Equation (4), including the intercept  $\alpha$  and the error term  $e$ .

The empirical strategy of this study is built on the above mentioned eight models which examine the impact of R&D expenditure and R&D intensity on our dependent variable sales growth. The reason for why these models have been formulated is to gain a better understanding of the R&D-growth relationship by also including variables (firm size, firm age and sector belonging) that may affect it according to previous research (Spescha, 2019; Chung et al., 2019). In this sense, we found it appropriate to include these variables in our study.

## 4. Results

On the upcoming two pages the empirical results of the study are shown as Table 3 and 4. Table 3 discloses the unstandardized beta of the coefficients in Equation I, II, III and IV with R&D expenditure as the independent variable. Table 4 includes the unstandardized beta of the coefficients in Equation V, VI, VII and VIII with R&D intensity as the independent variable.

**Table 3. OLS estimates: R&D Expenditure**

<b>DV: <math>s_{i,t} - s_{i,t-1}</math></b>	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>
$r_{i,t-3}$	-0,01 (0,01)	-0,02 (0,01)	0,01 (0,05)	0,04 (0,06)
$m_{i,t}$	< 0,01 (0,00)	< -0,01 (0,00)	< 0,01 (0,00)	< -0,01 (0,00)
$r_{i,t-3} \times m_{i,t}$		< 0,01 (0,00)		< 0,01 (0,00)
$r_{i,t-3} \times a_{i,t}$			-0,02 (0,03)	-0,04 (0,04)
$a_{i,t}$			0,15 (0,16)	0,27 (0,21)
SB: Basic materials		-0,02 (0,03)	-0,03 (0,03)	-0,02 (0,03)
SB: Consumer Cyclicals		-0,02 (0,02)	-0,02 (0,02)	-0,02 (0,02)
SB: Consumer Non-Cyclicals		-0,02 (0,03)	-0,02 (0,03)	-0,02 (0,03)
SB: Financials		-0,07 (0,04)	-0,06 (0,05)	-0,06 (0,05)
SB: Healthcare		< 0,00 (0,02)	0,01 (0,02)	0,01 (0,02)
SB: Technology		0,01 (0,02)	0,02 (0,02)	0,02 (0,02)
Constant	0,09 (0,05)	0,10 (0,06)	-0,10 (0,27)	-0,27 (0,32)
Observations	506	506	506	506
R-Squared	0,01	0,02	0,03	0,03

Notes: OLS estimates (unstandardized Beta) for regression equations I, II, III and IV. Std. dev. within parenthesis. P-value: \* = < 0,10 \*\* = < 0,05 \*\*\* = < 0,01

**Table 4. OLS estimates: R&D Intensity**

<b>DV: <math>s_{it} - s_{it-1}</math></b>	<b>V</b>	<b>VI</b>	<b>VII</b>	<b>VIII</b>
$m_{i,t}$	< -0,01 (0,00)	< 0,01 (0,00)	< -0,01 (0,00)	< 0,01 (0,00)
$r_{i,t-3}/s_{i,t}$	***-0,04 (0,01)	***-0,08 (0,01)	-0,06 (0,08)	-0,01 (0,08)
$r_{i,t-3}/s_{i,t} \times m_{i,t}$		* < 0,01 (0,00)		** < 0,01 (0,00)
$r_{i,t-3}/s_{i,t} \times a_{i,t}$				-0,05 (0,05)
$a_{i,t}$				-0,07 (0,13)
SB: Basic materials		-0,4 (0,03)	-0,04 (0,03)	-0,04 (0,03)
SB: Consumer Cyclical		-0,02 (0,02)	-0,01 (0,02)	-0,01 (0,02)
SB: Consumer Non-Cyclical		-0,03 (0,03)	-0,03 (0,03)	-0,03 (0,03)
SB: Financials		-0,06 (0,05)	-0,05 (0,05)	-0,06 (0,05)
SB: Healthcare		**0,06 (0,02)	*0,07 (0,02)	**0,06 (0,02)
SB: Technology		***0,06 (0,02)	*0,06 (0,02)	***0,06 (0,02)
Constant	-0,03 (0,02)	-0,10 (0,03)	-0,08 (0,12)	0,01 0,13
Observations	506	506	506	506
R-Squared	0,03	0,07	0,07	0,08

Notes: OLS estimates (unstandardized Beta) for regression equations V, VI, VII and VIII. Std. dev. within parenthesis. P-value: \* = < 0,10 \*\* = < 0,05 \*\*\* = < 0,01

## 4.1 R&D expenditure and sales growth

In Table 3 none of the variables are statistically significant, all showing p-values above 0,05. Column I show that higher levels of R&D expenditure are not significantly related to higher sales growth rates. Rather, since both the dependent and independent variables are logarithmic this means that a 1% change in R&D spending has a -0,014% effect on sales. This means that higher levels of R&D expenditure are not associated with higher sales growth rates. Thus, firms that increase their R&D expenditure do not grow faster in terms of sales.

Column II presents the results which builds on to regression equation I by including an interaction term between R&D expenditure and firm size (=market value). Like column I, the relationship between R&D expenditure and sales growth is still negative and not significant. Likewise, observing the coefficient of the newly introduced interaction term between R&D expenditure and firm size is not significant. This implies that there is no interaction effect between R&D expenditure and firm size on firms' sales growth, larger firms that account for R&D expenditure do not experience higher sales growth.

Observing Column III, the regression equation builds on to equation I by including an interaction term between R&D expenditure and firm age. Examining the coefficient of R&D expenditure, it has increased slightly to become positive in model III compared to model II. However, it is not significant which implies that higher R&D expenditure does not lead to increased sales growth. Furthermore, the coefficient of the firm age variable is not significant, meaning that older firms do not experience higher sales growth. Furthermore, adding the coefficient of the interaction term between R&D expenditure and firm age, the R&D and sales growth relationship becomes negative. Nevertheless, it is insignificant which implies that there is no relationship between older firms that invest in R&D and sales growth.

Column IV presents the estimation of the full model, including firm size, firm age, both respective interaction terms and the sector belonging variable. Column IV shows that the coefficient of R&D expenditure is insignificant, meaning that there is no relationship between R&D expenditure and sales growth. Furthermore, observing the coefficient of the interaction term between R&D expenditure and firm size our findings imply that it is insignificant to sales growth. Thus, there is no relationship between larger firms that invest in R&D expenditure and

sales growth. Moreover, the coefficient of the interaction term between R&D expenditure and firm age is insignificant on the 5% level. This implies that older firms that invest in R&D do not experience higher sales growth.

In sum, Table 3 shows that R&D expenditure has no impact on firm growth. Likewise, controlling for firm age, firm size and sector belonging, the empirical results imply that there is an insignificant impact of R&D expenditure on firm growth.

## 4.2 R&D intensity and sales growth

The empirical results in Table 4 provided new statistically significant results compared to those presented in Table 3. Comparing the results in Table 3 with Table 4 there emerge three diverging patterns between the results. First, observing Table 4, the coefficient R&D intensity is significant in both column V and column VI. In column V the small but negative significant coefficient of R&D intensity implies that for every 1% change in the intensity of R&D expenditure has a -0,04 effect on the firms' sales growth. This impact becomes slightly more negative in column VI after the firm size interaction term is introduced. Thus, we can conclude that increasing R&D intensity leads to a negative sales growth in the firms included in our sample. Compared to our main regression in Table 3 this is a significant result as the R&D expenditure coefficient showed insignificant results in relation to sales growth.

Second, another new statistically significant result from Table 4 is the positively significant coefficient of the interaction term between R&D intensity and firm size. This positively significant coefficient shows that larger firms that have high R&D intensity experience higher sales growth than small firms. In Table 3 this coefficient showed no significance in the four models.

Third, observing the sector belonging variables, the healthcare and technology sectors show significance in all regression models with R&D intensity. This is a new finding that was not observed in our regressions in Table 3. Like maintained in the findings by Chen, Guo, Chen and Wei (2019), R&D intensity can play a role in the impact of R&D on firm growth. They conclude that while R&D input does not always have a positive impact on firms' performance, there seems to be a correlation between R&D intensity and the industrial sector to which the

firm belongs. In this sense, to gain the benefits of investing in R&D firms need to dedicate time and effort in their R&D activity. In turn, like implied by our findings, the sectors in our data sample show a reflection of R&D intensity in the firms' sales growth. In equation VI to VIII, the coefficient of the healthcare sector shows a positive significance in relation to sales growth. Similarly, the coefficient of the technology sector shows a positive significance in relation to sales growth. This implies that firms in the healthcare and technology sector that increase their R&D intensity experience positive sales growth. Likewise, larger firms in these sectors that increase their R&D intensity experience the same positive growth path. In this sense, there is an apparent significant interaction effect between firm size and R&D intensity in the healthcare and technology sector that positively impacts the firms' sales growth. This finding is not unexpected as the healthcare and technology sectors devote large sums to R&D and technological development.

In sum, the coefficient R&D intensity is clearly significant already in column V, this is a new finding from our regression models with R&D intensity as the R&D expenditure coefficient showed a negative but no significant result in relation to sales growth in the regression models in Table 3. Moreover, the coefficient of the interaction term between R&D intensity and firm size is positive and significant. Lastly, the technology and healthcare sectors show positive significance to sales growth with the independent variable R&D intensity. In this sense, the statistical significance varies between the regression models in Table 3 and 4.

Observing the R-squared value in Table 4, the percentage of variance in the dependent variable that the independent variable R&D intensity explains collectively is strengthened throughout the regression models. The R-squared value is the highest in the full regression model in column VI, 0,08. Comparing it with the full regression model in Table 3 with R&D expenditure as the independent variable, the R-squared value is lower, 0,03.

## 5. Analysis and discussion

This section starts by analyzing the results shown in Table 3 and lists potential reasons as to why no significant relationship between R&D expenditure and firm growth could be established. We also contrast our results to those of previous scholars. The second part discusses the data output presented in Table 4 where we used R&D intensity as the independent variable. Lastly, we consider the results of the two tables in conjunction.

Not finding statistically significant results between sales growth and R&D expenditure in model I was initially surprising since there has, as accounted for in this thesis' literature review, been shown that R&D indeed can boost sales specifically (Morberly and Reithner, 1990). In conjunction with this we knew from our initial research that R&D intensive environments, such as the tech industry, showed a stronger relationship with firm growth (Chan, Kensinger and Martin, 1990; Zantout and Tsetsekos, 1994), contrasting low-tech industries, where instead a negative relationship was found (Chen, Hsieh and Yu, 2010). Examining our sample constellation, we note how technology actually is the economic sector with the highest occurrence (Figure 1 for reference). Building on the findings of previous academia that would increase our chance of identifying statistically significant results. It is however possible that although technology, tied with industrials, is the sector containing the highest number of companies in our sample it is still relatively small in terms of the number of included companies. Only 12 firms within the sector are accounted for, most likely impacting our ability to find significant results.

From Table 3 we note how while no statistically significant positive relationship between R&D expenditure and sales growth could be observed, neither could a statistically significant negative one be found. If R&D expenditure cannot be linked to firm growth, could it then potentially at least mitigate firm decline? We already know from our literature review how several company specific factors affect how much firms would expect to grow from their R&D activities. Older firms are often found to be better equipped to reach considerable growth as they have over time learned how to maximize their operations (Coad and Rao (2010), while larger entities rarely face the same risks with their R&D investments compared to smaller firms (Audretsch, Segarra and Teruel, 2014). This could explain a scenario where smaller, more cash-strapped firms that struggle to reach firm growth from their R&D activities compared to larger,

financially strong players, can at least instead capitalize partly on made investments. This could then allow these smaller and younger players to offset a shrinkage of their business.

Table 4 is where we observe our statistically significant findings, both column V and VI have a clearly statistically negative relationship between R&D intensity and sales growth. Although the negative coefficient is small (indicating minor movements in sales growth for each unit change in R&D intensity) it is in line with parts of previous research that R&D intensity will not necessarily boost the business. Furthermore, our results partly contrast those of Nivoix and Nguyen (2012) who found a positive link between R&D intensity and eminent firm growth in their thesis, but also stated that:

*“[...] high-R&D firms do not exhibit abnormal returns. When they are found to outperform in down markets, this is attributed to their lower book-to-market (higher growth characteristics) and the fact that growth firms tend to outperform in bad times. When they tend to trail in up markets, this is explained by their larger size and the fact that large firms under-perform in good times.” (ibid., 918).*

This indicates that R&D intensity, while at times generating tangible growth, is by no means a certain answer to a given outcome of firm growth (ibid.). This could in part explain why we for our sample note a small negative relationship. Had we for instance been able to increase our sample size it is possible that other findings, in line with previous academia, would have emerged.

Our other statistically significant findings include the positive relationship for our interaction term R&D intensity and firm size to firm growth. Through this finding we build on the work of Nivoix and Nguyen (2012) who as previously mentioned that firm size impacts how entities manage their R&D spendings. The authors stress that selected R&D intensity levels within firm size is by no means a guarantee for higher sales, which would link to why our observed relationship between our dependent variable and the interaction term is so small. Our results that larger companies would be more successful in reaching top line growth through higher R&D intensity than smaller firms could have several explanations. One possible answer is that larger firms often have more substantial sales than smaller firms which, as per the definition of R&D intensity, implies that more resources are allocated to a project or product development. This can then in turn be the difference between successful and unsuccessful products, which

would then either enhance or hamper the company's sales growth. Moreover, another possible explanation for our observed findings of our interaction term between R&D intensity and sales growth can be depicted from the fact that previous scholars have uncovered that firms, depending on their size, target different ways to grow (Demirel and Mazzucato, 2012). Nevertheless, for small firms R&D intensity is not always the strongest driver of firm growth (ibid.), while it proves to be an important tool and metric for larger SMEs (Nunes, et al., 2013). This would play a large role in the positive relationship in the interaction term as larger firms have more to lose (or stand to gain more) from their R&D activities than smaller firms. Larger firms would thereby be more incentivized to make the most out of their investments, while smaller businesses would perhaps map out other ways to achieve growth such as ad campaigns, gather external capital or merge forces with other companies.

Viewing R&D expenditure and R&D intensity in conjunction one should note how the two, although similar metrics, need to be interpreted differently as R&D expenditure "[...] is more closely aligned with the overall scale of a firm's technological activities" (Schoenecker and Swanson, 2002, p. 37), while R&D intensity "provides more information on the emphasis that the firm is placing on R&D in its competitive strategy" (ibid.). In other words, from our sample we are unable to make any statements regarding the impact of absolute spending on R&D activities whereas the ratio metric R&D intensity provides more conclusive evidence. Obtaining statistical significance for R&D intensity in our sample but not so for R&D expenditure could have several reasons. R&D intensity is sensitive to rapid decreases or increases in firms' sales, something that becomes particularly important to note when examining diversified companies (Schoenecker and Swanson, 2002, p. 37). Furthermore, in our sample we have, as shown in our descriptive statistics in Table 1, a large spread in the level of R&D expenditures whereas the R&D intensity variable is more gathered around a central value. An explanation for this could be because some firms might establish a limit of R&D intensity dependent on their sales, while this is not the case for absolute expenditure on R&D activities. Adding to this our sample's largest economic sector is technology (along with industrials), known for being an R&D intense environment. It is perhaps possible that firms within that segment will strive even more than others to ensure an optimal R&D expenditure to sales ratio, rather than just spending high absolute numbers on an investment.

## 6. Robustness test

We tested our data using alternative specifications to verify the robustness of our results. Examining previous literature, research effort takes about 2-3 years to materialize in results (Hall, Mairesse, and Mohnen, 2010; Huang and Yang, 2005). In our main regressions with R&D expenditure and R&D intensity we develop models that investigate the R&D-growth relationship adopting three years of lag on the independent variables. Nevertheless, to control for potential differences on the impact of our independent variables on our dependent variable sales growth, we developed regression models in our robustness test with one and two years of lag of R&D expenditure and R&D intensity. In this sense, the equations in our robustness tests follow the same structure as in our main regression equations. The four tables with one and two years of lag of R&D expenditure and R&D intensity respectively are found on the upcoming four pages, before reflections are presented.

**Table 5. Robustness test. R&D Expenditure with 1 year lag.**

DV: $S_{it}$ — $S_{it-1}$	I	II	III	IV
$m_{it}$	< -0,01 (0,00)	< -0,01 (0,00)	< -0,01 (0,00)	< -0,01 (0,00)
$r_{it-3}$	< -0,01 (0,01)	-0,01 (0,01)	0,03 (0,05)	0,07 (0,06)
$r_{it-1} \times m_{it}$		< 0,01 (0,00)		< 0,01 (0,00)
$r_{it-1} \times a_{it}$			-0,03 (0,03)	-0,05 (0,04)
$a_{it}$			0,18 (0,17)	0,32 (0,21)
SB: Basic Materials		-0,03 (0,03)	-0,03 (0,03)	-0,03 (0,03)
SB: Consumer Cyclical		-0,02 (0,02)	-0,02 (0,02)	-0,02 (0,02)
SB: Consumer Non-Cyclical		-0,02 (0,03)	-0,02 (0,03)	-0,02 (0,03)
SB: Financial		-0,07 (0,05)	-0,06 (0,05)	-0,06 (0,05)
SB: Healthcare		0,01 (0,02)	0,01 (0,02)	0,01 (0,02)
SB: Technology		0,20 (0,02)	0,02 (0,02)	0,02 (0,02)
Constant	0,05 (0,05)	0,05 (0,06)	-0,21 (0,27)	-0,4 (0,32)
Observations	506	506	506	506
R-Squared	0,02	0,02	0,02	0,02

Notes: OLS estimates (unstandardized Beta) for robustness test with R&D expenditure 1 year lag. Std. dev. within parenthesis. P-value: \* = < 0,10 \*\* = < 0,05 \*\*\* = < 0,01

Table 6. Robustness test. R&D Intensity with 1 year lag.

DV: $s_{it} - s_{it-1}$	V	IV	IIV	IIIV
$m_{it}$	< -0,01 (0,00)	< 0,01 (0,00)	< -0,01 (0,00)	< 0,01 (0,00)
$r_{it-1}/s_{it}$	***-0,03 (0,01)	***-0,07 (0,02)	-0,06 (0,08)	< 0,01 (0,09)
$r_{it-1}/s_{it} \times m_{it}$		**< 0,01 (0,00)		**< 0,01 (0,00)
$r_{it-1}/s_{it} \times a_{it}$			< -0,01 (0,05)	-0,05 (0,06)
$a_{it}$			< 0,01 (0,08)	-0,08 (0,09)
SB: Basic Materials		-0,05 (0,03)	-0,04 (0,03)	-0,05 (0,03)
SB: Consumer Cyclical		-0,02 (0,02)	-0,14 (0,02)	-0,02 (0,02)
SB: Consumer Non-Cyclical		-0,03 (0,03)	-0,02 (0,03)	-0,03 (0,03)
SB: Financials		-0,06 (0,05)	-0,06 (0,05)	-0,06 (0,05)
SB: Healthcare		**0,05 (0,20)	**0,05 (0,02)	**0,05 (0,02)
SB: Technology		**0,05 (0,02)	**0,05 (0,02)	**0,05 (0,02)
Constant	-0,02 (0,02)	-0,8 (0,03)	-0,08 (0,12)	0,03 (0,13)
Observations	506	506	506	506
R-Squared	0,02	0,06	0,06	0,06

Notes: OLS estimates (unstandardized Beta) for robustness test with R&D intensity 1 year lag. Std. dev. within parenthesis. P-value: \* = < 0,10 \*\* = < 0,05 \*\*\* = < 0,01

Table 7. Robustness test. R&D Expenditure with 2 year lag.

DV: $s_{it} - s_{it-1}$	I	II	III	IV
$m_{it}$	< 0,01 (0,00)	< -0,01 (0,00)	< 0,01 (0,00)	< -0,01 (0,00)
$r_{it-2}$	-0,01 (0,01)	-0,01 (0,01)	0,01 (0,05)	0,05 (0,06)
$r_{it-2} \times m_{it}$		< 0,01 (0,00)		< 0,01 (0,00)
$r_{it-2} \times a_{it}$			-0,02 (0,03)	-0,04 (0,04)
$a_{it}$			0,15 (0,17)	0,29 (0,21)
SB: Basic Materials		-0,02 (0,03)	-0,03 (0,03)	-0,03 (0,03)
SB: Consumer Cyclical		-0,02 (0,02)	-0,02 (0,02)	-0,02 (0,02)
SB: Consumer Non-Cyclical		-0,02 (0,03)	-0,02 (0,03)	-0,02 (0,03)
SB: Financials		-0,08 (0,05)	-0,06 (0,05)	-0,06 (0,05)
SB: Healthcare		< 0,01 (0,02)	0,01 (0,02)	0,01 (0,02)
SB: Technology		0,01 (0,02)	0,02 (0,02)	0,02 (0,02)
Constant	0,08 (0,05)	0,09 (0,06)	-0,12 (0,27)	-0,31 (0,32)
Observations	506	506	506	506
R-Squared	< 0,01	0,02	0,02	0,03

Notes: OLS estimates (unstandardized Beta) for robustness test with R&D expenditure 2 year lag. Std. dev. within parenthesis. P-value: \* = < 0,10 \*\* = < 0,05 \*\*\* = < 0,01

**Table 8. Robustness test. R&D Intensity with 2 year lag.**

DV: $s_{it} - s_{it-1}$	I	II	III	IV
$m_{it}$	< -0,01 (0,00)	< 0,01 (0,00)	< -0,01 (0,00)	< 0,01 (0,00)
$r_{it-2}/s_{it}$	***-0,04 (0,01)	***-0,08 (0,01)	-0,07 (0,08)	-0,01 (0,00)
$r_{it-2}/s_{it} \times m_{it}$		**< 0,01 (0,00)		**< 0,01 (0,00)
$r_{it-2}/s_{it} \times a_{it}$			< 0,01 (0,05)	-0,05 (0,06)
$a_{it}$			< 0,01 (0,08)	-0,07 (0,09)
SB: Basic Materials		-0,04 (0,03)	-0,04 (0,03)	-0,04 (0,03)
SB: Consumer Cyclical		-0,02 (0,02)	-0,12 (0,02)	-0,02 (0,02)
SB: Consumer Non-Cyclical		-0,04 (0,03)	-0,03 (0,03)	-0,04 (0,03)
SB: Financials		-0,06 (0,05)	-0,05 (0,05)	-0,06 (0,05)
SB: Healthcare		**0,05 (0,02)	**0,06 (0,02)	**0,05 (0,02)
SB: Technology		***0,06 (0,02)	***0,06 (0,02)	***0,06 (0,02)
Constant	-0,31 (0,02)	-0,1 (0,03)	-0,1 (0,12)	0,01 (0,13)
Observations	506	506	506	506
R-Squared	0,02	0,08	0,07	0,08

Notes: OLS estimates (unstandardized Beta) for robustness test with R&D intensity 2 year lag. Std. dev. within parenthesis. P-value: \* = < 0,10 \*\* = < 0,05 \*\*\* = < 0,01

## 6.1 R&D expenditure and R&D intensity one-year lag

In Table 5, the independent variable R&D expenditure is lagged one year to investigate the R&D-growth relationship. Observing the coefficient of R&D expenditure in equation 1 it is insignificant in relation to sales growth. This indicates that a one-year lag of R&D expenditure does not show any relationship to firms' sales growth. In turn, this finding in our robustness test conforms to our finding in Table 3 where the coefficient of R&D expenditure showed insignificance to sales growth. Furthermore, introducing the coefficient of the interaction term between R&D expenditure and firm size in equation 2, the coefficient shows no relationship to sales growth. Thus, larger firms that invest in R&D do not experience higher sales growth with a one-year lag of R&D expenditure. Likewise, in equation 3 the coefficient of the interaction term between R&D expenditure and firm age is insignificant, meaning that older firms that invest in R&D do not experience higher growth in terms of sales. Lastly, observing the full regression model with all the variables in equation IV, our findings indicate that there is no relationship between R&D expenditure lagged one year and sales growth.

Table 6 shows the regression outputs with R&D intensity lagged one year as the independent variable. From our regression output in column V, we can observe that the coefficient of R&D intensity shows a small negative but clear significance to sales growth. Introducing the variable firm size, the output from equation VI shows that the interaction term between R&D intensity and firm size is slightly positive and significant. In this sense, we find a relationship between R&D intensity lagged one year and firms' sales growth. Thus, larger firms that increase their R&D intensity experience a positive increase in sales growth. Furthermore, the coefficient of the R&D intensity variable is slightly more negative and significant to our dependent variable sales growth. Moreover, introducing the firm age variable in equation VII, the coefficient of the interaction term between R&D intensity and firm age shows no significance. This implies that older firms that increase their R&D intensity do not experience increased sales growth. Observing the coefficient of R&D intensity it is no longer insignificant in the regression output of equation VII. Lastly, observing the full equation in column VIII, the coefficient of R&D intensity shows no significance to sales growth like in column VII. Nevertheless, the interaction term between R&D intensity and firm size is still slightly positive and significant.

Comparing the findings in Table 5 and 6, the coefficient of R&D intensity shows a relationship with sales growth compared to R&D expenditure. Thus, our robustness tests with one year lag of the independent variable R&D intensity supports our findings in Table 4 with three years lag of the variable.

## 6.2 R&D expenditure and R&D intensity two-year lag

In Table 7, the independent variable R&D expenditure is lagged two years to examine the R&D-growth relationship. From our regression output in equation I-IV we can observe that the coefficient of R&D expenditure is insignificant in relation to sales growth. Furthermore, introducing the interaction term between R&D expenditure and firm size in equation II, Table 7 shows that there is no significant impact of firm size on the R&D-growth relationship. Observing equation III with the coefficient of the interaction term between R&D expenditure and firm age there is no significance of the coefficient, meaning that firm age has no direct impact on the R&D-growth relationship. Looking at the full regression model with all the variables together in column IV, the regression outputs imply that there is no relationship between R&D expenditure and firm growth.

In sum, comparing the regression output from Table 7 with two-year lag of R&D expenditure with Table 3 showing three years lag of the variable, the findings are consistent with each other. This implies that a one-year lag of R&D expenditure does not impact the R&D-growth relationship, verifying the robustness of our results in our main findings in Table 3.

Table 8 shows the regression outputs with R&D intensity as the independent variable that is lagged two years to examine the R&D intensity-growth relationship. In equation V we can observe that the coefficient of R&D intensity is slightly negative and significant in relation to sales growth. In this sense, firms that increase their R&D intensity experience slightly negative sales growth. This finding is in line with the results of the main regression model in Table 3 with R&D intensity as the independent variable, verifying the robustness of our result. In equation VI in Table 8, introducing the firm size variable, the coefficient of the interaction term between R&D intensity and firm size is slightly positive and significant. This implies that larger firms that increase their R&D intensity experience a small increase in sales growth. Equation VII shows that the coefficient of the interaction term between R&D intensity and firm age is

insignificant. Thus, older firms that increase their R&D intensity do not experience higher growth in terms of sales. Lastly, Equation VIII in Table 8 with all the variables together show no significance in the coefficient of R&D intensity, and the interaction term between R&D intensity and firm age. Nevertheless, the coefficient of the interaction term between R&D intensity and firm size is still slightly positive and significant to sales growth.

Comparing the empirical results in Table 7 and 8, our findings imply that R&D intensity shows a relationship to firm growth compared to R&D expenditure which shows no statistically significant results to firm growth. These results conform to the findings in our main regressions in Table 3 and 4 that R&D intensity and not R&D expenditure shows a significant relationship to firm growth.

### 6.3 Analysis and discussion of robustness test

R&D activity is a continuous process, and the returns R&D investments cannot be reflected in the same year of the R&D activities. Thus, it is necessary to take time into consideration when examining the impact of R&D (Yang, 2010). Observing the findings from our robustness tests with one and two years of lag on the independent variables R&D expenditure and R&D intensity, it can be inferred that the time lag effect of one and two years do not change the R&D-growth relationship in a significant manner. Nevertheless, the significance of the coefficient of R&D intensity is slightly more negative with two years of lag, -0,04 and -0,08, compared to one year of lag, -0,03 and -0,07, while the coefficient of R&D expenditure is still insignificant. This implies that there is a slightly more negative impact of R&D intensity on firms' sales growth with a lag of two years. Moreover, the findings of the lag period of two years is consistent with the lag period of three years of the independent variables in our main regression models. However, the coefficient of the technology and healthcare sector show the highest positive significance in Table 3 with three years lag. Linking into this, Zheng, Huang and Zhuang (2015) found that the effect of R&D is most visible with three years of lag. Hall, Mairesse, and Mohnen (2010) and Huang and Yang (2005) argue that research effort takes about 2-3 years to materialize in results. In this sense, our main regression outputs with three years lag support this finding as we can observe a more negative significant impact of R&D intensity on sales growth going from one year of lag to three years lag

## 7. Conclusion

The main purpose of this study is to enhance the analysis of the impact of R&D on firms' growth. An OLS regression has been adopted for a sample size of 46 firms listed on Nasdaq Stockholm for the 2006-2019 period. Following recent literature (Chung et al., 2019; Spescha, 2019) we present models with R&D expenditure and R&D intensity as the main mechanisms of firm growth, defined as sales growth. Firm size, firm age and sector belonging determining the R&D and sales growth relationship are also investigated.

Our study shows an insignificant impact of R&D expenditure on firms' sales growth. Likewise, controlling for firm age, firm size and sector belonging, the coefficients show no significant impact on the R&D expenditure-growth relationship. An insignificant relationship between R&D expenditure and firm sales growth is consistent with parts of previous literature which maintain that R&D is not regarded as a major factor that impacts firm growth (Brouwer et al., 1993; Demirel and Mazzucato, 2012; Freel and Robson, 2004). Thus, this paper adds to the empirical evidence suggesting that devoting a higher proportion of your sales to R&D activities does not generate firm growth.

Looking at R&D intensity we can find statistically significant insights. Observing the R&D intensity variable, the impact of the variable is slightly negative and significant. This implies that every change in R&D intensity has a small but negative impact on firms' sales growth. This implies that there is a direct significant and slightly negative relationship between R&D intensity and sales growth. This is an important finding which indicates that looking at the amount of R&D expenditure as a percentage of firm sales and not as an absolute number shows a significant relationship to firms' sales growth. Furthermore, controlling for firm size, the coefficient of the interaction term between R&D intensity and firm size is significant and slightly positive. On the other hand, the interaction term between R&D intensity and firm age shows no significance to the R&D intensity-growth relationship.

In sum, analyzing the findings of the regression models of this study, R&D intensity shows a slightly negative significance to sales growth, while R&D expenditure does not show any significance to sales growth. The results of this paper suggest that resources devoted to R&D in firms do not get translated into increased firm growth. This raises the question whether it is

worth investing in R&D and that policy makers should encourage firms to pursue other routes to increase firm growth.

## 8. Limitations and further research

Our study builds its approach and method heavily on the works of Spescha (2019) while providing additional insights through our inclusion of R&D intensity as a main part of the thesis. Partly following a method claimed by an already published article we strived to make sure that high quality is maintained throughout the paper. Despite our work's close link to previous scholars and academic articles there are limitations to our research. This section seeks to discuss them while also conveying suggestions on how future research could build on our findings.

First, even though the choice to include multiple economic sectors as a control variable brought something rather new to the field (as much of the published work focuses on only one industry or sector) it is possible that it strained the accuracy of our chosen models. Had we gone with the more standardized approach of targeting one single sector such as technology it is possible that we could have been able to explore and analyze potential findings deeper.

Second, since we achieved statistical significance for one R&D metric, R&D intensity, but not the other, R&D expenditure, this raises questions regarding if R&D expenditure is indeed the most fitting metric to study given our sample and results. As accounted for in our literature review, we examined the work of previous scholars closely before selecting the two included R&D metrics. Nevertheless, choosing other R&D metrics, such as patents, could potentially have resulted in other findings.

Regarding future research we note how there are divergent results when measuring how two similar metrics, R&D expenditure and R&D intensity, affects firm growth. To be able to provide a more wholesome picture of the relationship we would encourage future research to examine topics such as:

- Which one of R&D expenditure or R&D intensity would indeed prove the most suitable metrics to study when mapping R&D's relationship to firm growth?
- If R&D intensity is merely viewed by companies as a ratio that one seeks to hold constant as the firm grows or if there is a deeper wish to uncover the optimal ratio of R&D dollars spent per dollar generated in sales?
- If there are specific settings, e.g., industries, where we with confidence can determine a suitable time lag to map the impacts of R&D expenditures on firm growth?

Finally, we would encourage future scholars to dig into the ever-lasting question of what constitutes the most accurate metric for stakeholders wishing to understand a firm's R&D activities. This thesis literature review covered where current research stands on the topic to date, but it is highly possible that R&D is not captured solely in numbers and traditional quantitative metrics. When asked how they manage R&D one senior leader at the Swedish engineering giant Epiroc stated that:

*“R&D goes beyond the numbers appearing in the financial reports. R&D and innovation is about how we work at the company, how we reflect, think and act. It is about mindset.”*

How to measure and showcase the impact of such a concept of R&D is probably where the rubber meets the road in understanding how R&D affects the firms of tomorrow.

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# Appendix

## Appendix 1: Correlation Matrix

### Correlation Matrix

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Variable	$a_{i,t}$	$m_{i,t}$	$r_{i,t-3}$	$r_{i,t-3}/s_{i,t}$	$s_{i,t} - s_{i,t-1}$
$a_{i,t}$	1				
$m_{i,t}$	0,25	1			
$r_{i,t-3}$	0,58	0,62	1		
$r_{i,t-3}/s_{i,t}$	-0,33	-0,05	-0,07	1	
$s_{i,t} - s_{i,t-1}$	0,04	-0,04	-0,07	-0,16	1

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Notes: Correlation matrix of the variables firm age, firm size, R&D expenditure, R&D intensity, and sales growth.

All variables are logged using the base 10 except for market value which has not been logged.

## Appendix 2: Included companies

ABB	MYCRONIC
ACTIVE BIOTECH	NET INSIGHT
ALFA LAVAL	NIBE INDUSTRIER
ANOTO GROUP	NOLATO
ASSA ABLOY	OREXO
ASTRAZENECA	ORTIVUS
ATLAS COPCO	PRECISE BIOMETRICS
BIOGAIA	PRICER
BIOTAGE	RAYSEARCH LABORATORIES
BOLIDEN	SAAB
CONCEJO	SANDVIK
ELECTROLUX	SENSYS GATSO GROUP
ELEKTA	SINTERCAST
ENEA	SKF
ENIRO	STUDSVIK
ERICSSON	SVENSKA CELLULOSA AKTIEBOLAGET SCA
FINGERPRINT CARDS	SWEDISH MATCH
GETINGE	TELIA COMPANY
HALDEX	TRADEDOUBLER
HEXAGON	TRELLEBORG
INDUTRADE	VBG GROUP
MIDWAY HOLDING	VITROLIFE
MULTIQ INTERNATIONAL	VOLVO

*Notes: Complete list of the 46 included companies in the thesis. Sorted alphabetically.*