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The Relationship Between R&D Intensity, Innovation & Firm Performance in the Nordics

by

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Abstract

Title	The Relationship Between R&D Intensity & Firm Performance in the Nordics
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Authors	Matias Braks & Jyri Eboreime
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Key words	Innovation, R&D intensity, firm performance, Nordic countries, panel data analysis
Purpose	The objective of this study is to explore Nordic innovation through R&D and its relationship to firm performance.
Theoretical framework	The theoretical framework is based on Knowledge-Based view, Resource-Based view and Dynamic capabilities theory which all focus on the collection and use of knowledge to create an advantage in the market place.
Methodology	This study employs panel data analysis through multiple ordinary least squares (OLS) regression models to investigate the relationship between R&D and firm performance.
Empirical findings	This study finds a bilateral relationship, where R&D intensity had a negative impact on firm performance. Evidence of a non-linear relationship between the variables was also evident.
Conclusions	The authors speculate that firms with higher R&D intensity, might have challenges transforming their R&D efforts into tangible financial outcomes. This suggests that the ability to effectively utilize and implement R&D investments plays a major role in achieving positive financial performance over a medium time frame. Policymakers are urged to cultivate an ecosystem, where researchers can harness these insights as a launching pad for further exploration.

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Abbreviations

KBV – Knowledge-Based View

R&D – Research and development

RBV – Resource-Based View

ROA – Return on assets

ROE – Return on equity

1 Introduction

1.1 Background

In order to advance society, technology, and economic growth, innovation is essential. Countries with a strong emphasis on innovation typically have higher levels of productivity, competitiveness, and overall development (WIPO, 2022). This creates an atmosphere that promotes innovative thinking and the pursuit of new ideas. Through innovation, firms can remain at the forefront of global trends and adapt to changing market conditions. A sign that demonstrates the significance of innovation is the correlation between research and development (R&D) expenditure and economic growth (Kafouros, et al., 2008). Generally, countries that allocate a large portion of their GDP to R&D activities have witnessed substantial financial gains (OECD 2021).

The Nordic region, which includes Finland, Sweden, Denmark, Norway, and Iceland, has long been recognized for its progressive economic policies, innovative business culture, and significant R&D investments (GII, 2022). The harmonious relationship between R&D intensity, innovation, and firm performance has piqued the interest of academics and practitioners. Understanding the relationship between R&D intensity and firm performance is critical in the Nordic countries because of their collective commitment to fostering a knowledge-driven economy and promoting sustainable development. The Nordic region's strong emphasis on innovation and technology can also be considered critical to its economic success. The Nordic countries have also become sites for startups, tech companies, and green innovations by encouraging research-driven entrepreneurship and fostering an environment conducive to innovation. As a result, even in the face of challenging global economic conditions, this has translated into economic resilience and growth (Nordic Coucil of Ministers, 2017).

The Nordic countries seem to be united in their support for progressive policies, sustainable development, and a strong emphasis on education and research. These factors have contributed to their reputation as leaders in a variety of global indices such as the Global Innovation Index (GII, 2022). Policymakers, business executives, and researchers

can all benefit from having a better understanding of the elements that stimulate innovation and affect firm performance in the Nordic region. This is why studying the dynamics between R&D intensity and firm performance becomes important, as it helps to further understand the importance of innovation within the region.

1.2 Purpose & Aim

A key element of the study is centered around R&D intensity, which refers to the investment of resources towards R&D activities within a firm. This thesis defines R&D intensity as the ratio of R&D expenditures to sales, since R&D expenditures are tied to a firm's commitment to innovation. This thesis employs R&D intensity as a proxy for innovation as it serves as an indicator of commitment to advancing progress and solutions (Kafouros, et al., 2008). The paper draws upon a variety of relevant literature. As main points of reference, this paper utilizes studies such as Chen & Ibhagui (2019), Chen et al. (2019), and Vithessonthi & Racela (2016). These studies provide useful insights and serve as benchmarks for comprehending the dynamics of R&D intensity and firm performance. Furthermore, to contribute to the research on this topic, this paper incorporates established theories from the fields of innovation studies, such as the Knowledge-Based View (Grant, 1996).

The primary purpose of this study is to investigate how R&D intensity impacts firm performance in Nordic countries. The study seeks to provide insights into the extent to which R&D intensity influences firm performance through a comprehensive analysis of relevant data and empirical research methods. To achieve this, the authors formulated the following research question:

Research question: What is the relationship between R&D intensity and firm performance within large-cap firms in the Nordic region?

The aim is to investigate, the largest listed firms in the region, commonly referred to as large-cap companies, over a ten-year period (2013-2022). Throughout the covered time period, these nations have consistently ranked among the world's leaders in R&D investment, nurturing an environment conducive to technological advancement and innovation-driven growth. As the chosen time frame spans a decade, this study will be able

to capture any temporal shifts in the relationships under investigation and shed light on the dynamics across the Nordic region during this period. As mentioned above, Nordic countries are well known for their high levels of innovation and technological developments. These countries have established themselves as global leaders in innovation and are known for creating an environment advantageous to R&D activities (State of the Nordic Region, 2016). By examining the Nordic region as a whole, this study aims to determine the collective impact of R&D intensity on firm performance. This approach is beneficial as it allows for an analysis of the Nordic countries' common traits and mutual influences in shaping the innovation environment. Furthermore, by treating the Nordic region as a whole, the study can provide insights on the distinct Nordic model of innovation and its results for firm performance.

As mentioned, the focus will be exclusively on large-cap firms within the Nordic region. This is because the authors argue that large-cap firms, due to their substantial resources, are more capable of investing in R&D activities. This capability could be seen in the potential to allocate sizeable financial resources, the ability to recruit and keep skilled workers, the ability to use cutting-edge technological infrastructure, and the decision to adopt a long-term strategic focus on innovation. The choice was made in light of the significant impact and sway large-cap firms have on regional economy and innovation. Furthermore, the performance of large-cap companies can be examined to gain important knowledge about the broader impacts of innovation on the Nordic economy and society. Studying this particular group enables a more focused examination of how R&D intensity impacts firm performance within the context of organizations with significant market reach and influence due to the distinctive challenges and opportunities that large-cap firms face. It is important to acknowledge that the emphasis on large firms could introduce biases, since it is possible that the results do not fully reflect the diversity and dynamism of the Nordic region's R&D landscape. The conclusions drawn from this study may thus primarily reflect the methods and results applicable to larger, more established corporations.

To focus the analysis, this paper excludes financial firms, real estate firms, and firms that reported zero R&D expenditure during the studied time-period. Financial and real estate firms exhibit different accounting standards and often engage in activities that are fundamentally different from other sectors, so their R&D expenditures are not directly comparable. The exclusion of firms reporting zero R&D expenditure ensures that attention

is placed on firms for whom R&D is an important and active pursuit. This exclusion may cause potential biased estimations by not representing the full population of firms, but the authors believe that including firms with zero R&D expenditure might not contribute meaningful data to address the research question.

1.3 Contribution

Through an examination of the relationship between R&D intensity and firm performance in the Nordic region, this paper aims to make significant contributions. By updating and extending the existing literature in both time and geographical context, the goal is to ultimately add to the knowledge base of the academic and business communities. Furthermore, most of existing research has taken place in earlier time-periods. Given the possible changes in the traits of R&D intensity and innovation over the years, this study aspires to offer insights into the modern dynamics between R&D intensity and firm performance in the Nordics. The strategy of concentrating on large-cap firms strikes a balance between the advantages of a targeted analysis and the awareness of potential biases, setting the stage for an investigation that is reflective of the complexity present in this field of study.

1.4 Outline

This research paper is divided into the following sections: The first section covers the theoretical background and literature review. The theoretical background introduces an overview of frequently used theories in R&D research. The literature review provides a review of the relevant literature, focusing on prior research related to R&D intensity, and firm performance. The second section outlines the data and research methodology, describing the dataset, variables, and statistical techniques employed in our analysis. The third section will present and discuss the results derived from our analysis and delve into an analysis of the implications of our findings. Finally, the paper concludes by summarizing the findings, addressing limitations, and making suggestions for future research.

2 Theoretical Background

An overview of some of the conventional theories used in research on R&D and firm performance can be found in the theoretical background section. The Knowledge-Based View (KBV) emphasizes a firm's knowledge base (Grant, 1996), while the Resource-Based View (RBV) theory places a strong emphasis on the value of a firm's assets and capabilities in gaining a competitive edge (Barney 1991). The Dynamic capabilities theory highlights a firm's ability to adapt and change over time (Teece et al., 1997). These theories all share the idea that R&D intensity is crucial components of a company's ability to succeed financially and maintain a competitive advantage.

2.1 Knowledge-Based View

A useful framework for comprehending how R&D intensity and innovation intensity affect firm performance is the Knowledge-Based View of the firm (KBV), since according to this theory, a company's knowledge base is a crucial asset that affects its ability to compete and, ultimately, its financial performance (Cuthbertson & Furseth, 2022; Grant, 1996; Vithessonthi & Racela, 2016). KBV provides a fundamental understanding of how R&D intensity can contribute to establishing and maintaining a competitive edge by recognizing knowledge as a strategic asset for firms. According to KBV, firms can use their knowledge assets to create a sustainable competitive edge, since this allows them to innovate and adjust to changing market conditions.

In the context of R&D intensity, it would be safe to assume that firms with high R&D intensity are more likely to acquire new knowledge, and by using this knowledge, the firm can possibly gain a competitive advantage. In turn, this knowledge encourages innovation and market adaptation, and it provides firms with the ability to create new products, improve existing processes, and counteract threats from the competition (Cohen & Levinthal, 1990). A firm's strategic agility, which strengthens its position in the market, is also shaped by its capacity to create, integrate, and apply knowledge (Nonaka & Takeuchi, 1995).

When it comes to the relationship between R&D intensity and firm performance, the KBV has limitations. The KBV does not entirely capture the complex link between firm performance and knowledge, which can be influenced by numerous factors such as industry characteristics and firm size (Grant, 1996). Therefore, in practice, KBV ought to be complemented with other points of view that consider the broader context in which R&D and knowledge accumulation occur.

This paper employs additional perspectives to supplement KBV in order to address KBV's limitations. The Resource-Based View (RBV), and the Dynamic Capabilities Theory provide additional insight into how firms can successfully leverage their knowledge resources and adapt to changing market conditions.

2.2 Resource-Based View

The theoretical framework, Resource-Based View of the firm (RBV) highlights the importance of a firm's resources in determining its competitive advantage (Barney, 1991). The theory states that a firm's resources can be divided into two categories: tangible resources and intangible resources. These resources might include things like physical assets, human capital, organizational culture, and information. In addition, RBV highlights the significance of the heterogeneity of resources as well as their immobility, indicating that a company's distinctive and valuable assets can't be replicated or transferred to other companies. According to RBV, for a resource to provide a firm with improved performance and a sustained competitive advantage, it must possess four key characteristics, which are referred to as VRIN (valuable, rare, inimitable, and non-substitutable): It should be valuable to help the firm capitalize on opportunities; it should be rare and not be in the possession of many competitors; it should be inimitable, which means that it is difficult to replicate; and finally, it should be non- substitutable which implies that it has no identical resource available (Bareny, 1991)

According to RBV, actions such as R&D expenditures can help a company make the most of its special assets and competencies, which could ultimately result in a long-lasting

competitive advantage. Furthermore, rare, and valuable resources, like patents, trademarks, and proprietary technologies, can be produced by a company's R&D activities and can be challenging for rivals to copy or replace. It is also important to note that recent research about RBV has emphasized the importance of knowledge-based resources, such as innovation, in order to attain a sustained competitive advantage (Cuthbertson & Furseth, 2022). Therefore, the KBV and RBV share a close relationship since both theories acknowledge the importance of knowledge and innovation in a firm's overall performance.

Similarly, to the KBV, the RBV has the limitation of not taking into account external factors that might affect a firm's success, such as changes in consumer preferences, regulations, or technological developments (Barney, 1991). Thus, RBV's focus on internal assets might not fully explain a company's financial performance. Furthermore, while RBV recognizes the importance of immobility and heterogeneity of resources, it doesn't provide specific instructions on how to acquire these resources, which can limit its practical utilization (Stinchcombe, 2000).

2.3 Dynamic Capabilities Theory

Similarly, to the theories discussed above, the main emphasis of the Dynamic Capabilities Theory (Teece et al., 1997) is on a firm's ability to change and adapt in response to changes in its external environment. According to the theory, firms that are able to do this generally have a higher chance of maintaining their competitive advantage and financial performance. One requirement to reach this state is for a company to build on its current capabilities by investing in R&D activities, which would enable it to develop dynamic capabilities. Dynamic Capabilities Theory, specifically in the context of R&D, suggests that R&D activities can help firms acquire new information and knowledge that can be tapped into to improve financial performance over time. For instance, this might entail having the capacity to quickly prototype new goods or obtain patents on new goods and services. By doing this, firms are capable of mitigating knowledge spillover and attracting investments.

The Dynamic Capabilities theory has a limitation in that it assumes that all firms have equal access to information and resources, which isn't the case in reality (Eisenhardt & Martin, 2000; Todorova & Durisin, 2007). It would make sense that larger firms tend to

have more resources and be better positioned to acquire new information and invest in R&D. As a result, large firms have an advantage over smaller firms. However, this limitation does not particularly affect the purpose of this thesis since it covers the largest firms within the Nordic region. Another limitation concerning the Dynamic Capabilities theory is that while R&D activities help firms adapt and change, they do not guarantee financial success by themselves because other factors need to be considered as well (Teece, 2007). One reason for this is that R&D expenditures do not always result in a positive return, which can negatively impact a firm's short-term financial performance (Vithessonthi & Racela, 2016). In addition, Lawson & Samson (2001) argue that it is difficult to identify and utilize the capabilities presented by the theory.

3 Literature Review

The aim of the literature review section is to provide readers a thorough understanding of the existing research on the subject by examining the key points of reference, evaluating earlier studies in the area, and investigating how R&D intensity affects firm performance. Overall, the literature review section will present a critical evaluation of the current state of knowledge on this topic and try to identify any gaps in the prior literature.

It is important to note that a firm's performance might also depend on other factors that are not thoroughly discussed in this paper. For example, research has shown that the impact of R&D intensity on firm performance varies depending on factors such as industry and competition (Cohen, et al., 1987). This is because the development of products in different industries requires significant investments in R&D and patent portfolios due to the lengthy development cycles before new drugs or biotech products can be launched. In addition, studies have found that the positive effect of R&D intensity on firm performance is stronger in high-tech firms than in low-tech firms, particularly in sectors where the protection of intellectual property and innovation is vital (Chen et al., 2019; Huergo & Jaumandreu, 2004).

3.1 R&D Intensity

There is a great deal of study has been done on the relationship between a firm's R&D intensity and performance. According to numerous studies, R&D intensity positively affects aspects of a firm's financial performance (Connolly & Hirschey, 2005; Gunday et al., 2011; Kafouros et al., 2008). Kafouros et al. (2008) discovered that R&D intensity has a positive effect on a firm's sales growth, profitability, and market value. Similarly, Gunday et al. (2011) discovered that R&D intensity positively affects a firm's market share and ROA. In addition to R&D's positive relationship with firm value, Connolly & Hirschey (2005) discovered that firm size also affects the significance of the relationship.

Some studies have discovered a non-linear relationship between R&D intensity and firm performance (Chen & Ibhagui, 2019). For instance, they discovered an inverted U-shaped relationship between R&D intensity and firm performance, with the positive effect of R&D intensity diminishing once a certain level of R&D investment is reached. The study argued that R&D activities can improve firm performance to a point, but the improvement does not last into perpetuity. However, prior research on the topic emphasizes that the correlation is rarely black and white, since multiple factors can influence the relationship between R&D intensity and firm value. There are also studies that illustrate the gray area or the lack of positive effects (Brouthers et al., 2005; Chen et al., 2019; Czarnitzki and Kraft, 2009; Vithessonthi & Racela, 2016). For example, according to Brouthers et al. (2004), small firms that select international markets consistently have higher R&D intensity. However, this does not always equate to improved firm performance, indicating that other aspects may be significant in determining the relationship between R&D intensity and performance. The authors of this paper speculate that there might be a bilateral relationship between R&D intensity and firm performance meaning that the relationship is reciprocal rather than one-sided, with both variables having an impact on one another.

The study by Vithessonthi & Racela (2016) investigated how R&D intensity and internationalization affect firm performance. The study adopted the KBV theory by illustrating that R&D intensity produces knowledge that improves a firm's financial performance. They used a sample of all non-financial publicly traded firms on the US Stock Exchange, and the study measured R&D intensity by using R&D expenditure as a percentage of sales. The study hypothesized that R&D intensity has a positive effect on firm value, and the results showed that R&D intensity has a positive effect on firm performance in the long- term but not in the short-term. In addition, the results reinforced the KBV theory (Grant, 1996).

Chen et al. (2019), investigated the relationship between R&D investment activities and firm performance, focusing on how R&D intensity and other internal operating factors affect firm performance. Their research looked to determine if large investments in R&D affected firm performance in the same period and if it continued to influence it in the next few periods. The findings showed that R&D investments have a positive and lag effect on the high-tech sector, which means that sizable R&D expenditures made during a certain period may have a negative impact on firm performance during that period and continue to have an impact during ensuing periods. The study also suggests that a larger firms tend to

use more resources for R&D, which results in better technologies and higher profits. Regardless of whether large firms are more capable of R&D intensity, Czarnitzki & Kraft (2009) suggest that firms with high debt levels are more likely to have lower levels of R&D investment and lower levels of innovation performance. They also discovered that firms with high levels of internal funds tend to have higher levels of R&D intensity, and the authors imply that financial constraints can be a vital factor in determining a firm's ability to invest in R&D.

3.2 R&D activities within the Nordic Region

While studies examining R&D intensity and firm performance in specific Nordic countries have been widely published, research examining the Nordic region as a whole is relatively underrepresented. The typical strategy is to look into these issues at the national level, considering the unique industrial and economic traits of each country. There may not be a large body of literature that is completely comparable to this study's focus on the relationship between R&D intensity and firm performance in the Nordic region. However, there are related studies that investigate this relationship within the context of individual Nordic countries or specific sectors. For instance, in Sweden, a study done by Lööf & Heshmati (2006), analyzed the role of R&D investments in molding firm performance across various industrial sectors. The study utilized a panel dataset of Swedish manufacturing and service firms, and they found that R&D intensity significantly contributed to productivity, particularly among high-tech firms. Furthermore, Laursen, K., and Salter, A. (2004) expand understanding of the role of R&D intensity within the firm's strategic landscape by highlighting how external R&D can affect performance in their study on open innovation and firm performance.

3.3 Hypothesis Development

The creation of the hypothesis in this study is based on identifying gaps in prior research and building upon predictions made from previous studies and theories. By analyzing existing literature and recognizing areas where the research can contribute new insights to, this study seeks to not only validate or challenge existing paradigms, but also explore avenues that may advance our understanding of the subject. While the emphasis on unexplored areas increases the study's originality, the alignment with prior research ensures a solid theoretical basis.

One noteworthy gap in the literature relates to the lack of research on R&D intensity within the Nordic countries as a collective group. While individual studies have investigated the intensity of R&D in particular Nordic countries, there is an absence of research that investigates R&D intensity across the entire Nordic region. This issue was previously touched upon in the introduction. To further elaborate, pooling the Nordic region as a whole has advantages, and individual countries' relationships between R&D intensity and firm performance have prior empirical literature.

The authors argue that one advantage of pooling the countries together is the homogeneous socio-economic factor. The Nordic countries share commonalities in their socio-economic and institutional frameworks, and this is commonly referred to as the Nordic model (Veggeland, 2014). This makes them an appropriate group for an united analysis. They display comparable levels of political stability, social welfare systems, and economic development, which can aid in adjusting for potential confounding variables in a more diverse cross-country study. Another advantage would be regional collaboration and knowledge transfer. In particular in the fields of research, innovation, and technology, the Nordic region has a long history of cooperation and knowledge exchange (Veggeland, 2014). Collectively, the Nordic countries have worked on joint projects to promote entrepreneurship, innovation, and sustainable development. The third advantage would be for statistical purposes. As this study focuses only on large-cap firms, combining the data from all the Nordic countries increases the sample size, which leads to more robust statistical results.

The concentration on large-cap firms stems from the fact that large firms exhibit greater

capabilities and market reach. As already mentioned, large firms tend to have a profound impact on regional economic areas (Cohen & Levinthal, 1990). Due to their ability to invest in significant research, new technological advancements, and the commercialization of ideas, large-cap firms generally serve as the primary drivers of innovation in the context of high R&D intensity (Chen et al., 2019). Furthermore, the knowledge-driven economy and commitment to innovation in the Nordic region are in line with the strategic direction taken by large-cap firms.

Based on the empirical literature covered, gaps in prior research, the theoretical frameworks mentioned above (KBV, RBV, & Dynamic Capabilities Theory), and considering the specific context of large-cap firms in the Nordic region, the following hypotheses are proposed:

Hypothesis 1:
Null Hypothesis (H01): There is no significant relationship between R&D intensity and firm performance among large-cap firms in the Nordic region.
Alternative Hypothesis (HA1): There is a significant positive relationship between R&D intensity and firm performance among large-cap firms in the Nordic region.

This hypothesis is based on the knowledge that large firms have the resources to invest in R&D projects that produce innovations and long-lasting competitive advantages (Grant, 1996; Barney, 1991).

Hypothesis 2:
Null Hypothesis (H02): There are no diminishing effects between R&D intensity and firm performance.
Alternative Hypothesis (HA2): There are diminishing effects between R&D intensity and firm performance.

This hypothesis is predicated on the notion that investments in R&D adhere to the principle of diminishing returns. For instance, according to empirical research by Chen & Ibhagui (2019), there is a critical level of R&D intensity beyond which the returns start to decline.

4 Methodology

The methodology section will cover how the data was collected, the research design, model variables, and regression models that are employed in this study. The study uses unbalanced panel data regression analysis to determine a significant relationship between R&D intensity and firm performance. The regression models take into account a number of independent variables that the study deems to be significant drivers of firm performance. Finally, the study will cover fixed-effects regression models. (See Appendix 2 for variable definitions)

4.1 Data Collection

In order to analyze the financial performance of the largest firms operating in the Nordic region, this paper used a dataset that was sourced from Capital IQ. Capital IQ is a financial data platform and research tool that provides comprehensive information and analysis on public and private companies, financial markets, industries, and investment research. It is widely used by finance professionals, investment analysts, portfolio managers, investment bankers, and other professionals in the financial industry. This source enhances the comprehensiveness and accuracy of the data used to examine the relationship between R&D intensity, innovation, and firm performance. Overall, the selection of Capital IQ as a data source in this study was motivated by its credibility and accuracy. This reputable source, recognized for its comprehensive coverage and quality control processes, ensures that the findings and conclusions drawn from the data are robust and reliable.

In this case, the researchers have collected data on a sample of firms operating in the Nordic countries over the past ten years (2013–2022). The selected time period for the study was chosen to build upon and extend existing literature. The study wants to offer current insights that reflect the newest trends and market dynamics, so it concentrates on the last ten years. It enables an analysis that not only makes sense in the current economic environment but also adds value by updating the field's body of knowledge. Furthermore, some existing literature suggests that the benefits of R&D intensity are not typically

identified from a short time-period (Vithessonthi & Racela, 2016). This is why this ten-year period captures the immediate affects while also providing for gradual changes.

The choice of companies is based on the OMX Nordic Large Cap index, which includes the 250 largest and most traded shares on the NASDAQ OMX Copenhagen, Helsinki, Stockholm, Iceland, and Oslo exchanges. The selection of the index as the basis for data collection can impact the results of the study, as the index represents a specific subset of companies from the Nordic region, comprising the largest and most influential firms in terms of market capitalization. By focusing on this index, the study narrows its scope to a specific group of firms, excluding smaller or less prominent firms that may also play a role in the relationship being investigated. Consequently, the findings may not be generalizable to the entire population of firms in the Nordic region or other regions outside the index's coverage. It is also important to note that while focusing on large-cap firms provides a focused and well-defined sample of companies, it is essential to recognize that the results may primarily reflect the characteristics and performance of the firms within this specific index. Care should be taken when generalizing the findings to the broader population of Nordic companies or other regions. However, as this paper's goal is to analyze large-cap firms within the Nordic region, the authors argue that this focused approach is beneficial since it allows for a concentrated analysis of the relationship between R&D intensity and firm performance, specifically with the firms that have significant influence and market reach.

As mentioned earlier in the paper, in order to conduct accurate research about the relationship between R&D intensity and firm performance, financial firms and real estate firms were excluded from the dataset. Financial and real estate firms, operate in a distinct industry with unique financial activities, regulations, and risk profiles. Their business models, ways of making money, and performance metrics are very different from those of firms in other sectors. As a result, including them in the dataset can greatly increase heterogeneity and skew the outcomes. Furthermore, firms that reported zero R&D expenditure during the selected time period were also excluded from the dataset. The decision was made since over a quarter of the firms on the index (after excluding financial and real estate firms) reported zero R&D expenditure, and the authors concluded that including a substantial number of zeros in the data may create problems with skewness, leading to irregularities in the distribution of the dependent variable. This can violate the assumptions of regression models, leading to biased estimates. Additionally, by excluding

firms with zero R&D expenditures, attention is given to companies for whom R&D is a significant endeavor. After excluding financial firms, real estate firms, firms with zero R&D expenditure, the final data set consisted of 120 firms on the OMX Nordic Large Cap index.

4.2 OLS regression

In this study, we use an ordinary least squares (OLS) regression with unbalanced panel data to analyze the relationship between R&D intensity and firm performance. Panel data analysis is a widely used technique in empirical research, especially when studying multiple observations of the same individuals, firms, or countries over time. Unbalanced panel data allows us to utilize all available observations, even if some firms have missing data for certain time periods. By employing this method, we can estimate the relationship between R&D intensity and firm performance while considering the entire dataset. This approach enables us to use all available data for each firm throughout the entire period, considering both individual differences and time-varying factors.

4.3 Research Design

This study will use a quantitative research design, specifically an unbalanced panel data regression analysis, to examine the relationship between R&D intensity and firm performance in the Nordic countries using the OMX Nordic Large Cap index. The panel data will include information from the past ten years (2013-2022) for a sample of firms operating in these countries. This choice of research design allows the researcher to establish a causal relationship between R&D intensity and firm performance in the Nordic countries. Additionally, panel data regression analysis is particularly useful because it allows for the examination of trends over time, which can reveal more detailed and nuanced relationships between variables. The choice to use fixed effects regression models over random effects was determined by a Hausman test (See Appendix 1). The fixed effects method is adopted to mitigate potential endogeneity concerns and individual heterogeneity in the analysis.

As mentioned earlier, the authors wonder if the relationship between R&D intensity and firm performance is bilateral. The connection between these variables is complex and

reciprocal and the relationship might not simply be one-directional. Improved firm performance may lead to increased investment in R&D, while higher R&D intensity may also enhance firm performance. Given this intricate interplay, our study employs regression models to delve into this relationship within the Nordic context. The ability of regression analysis to capture the nuances of this bilateral relationship, where various variables may interact complexly with one another, influences the choice of regression analysis. Regression models are well-suited to analyze how changes in one variable are associated with changes in another, allowing us to control for various factors and isolate the specific effects of R&D intensity on firm performance and vice versa.

The decision to employ fixed effects regression analyses in our study recognizes the need for a sophisticated and nuanced approach. These models offer the statistical flexibility to control for multiple factors simultaneously, providing insight into how R&D intensity and firm performance are linked both directly and indirectly. This methodological choice aligns with our goal to provide a comprehensive understanding of the dynamics between these essential economic variables within the unique context of the Nordic region's commitment to innovation and sustainable development.

By using the following regression models, we aim to contribute to the existing body of literature by offering an in-depth and tailored analysis of the Nordic region, respecting the complexity of the relationship between R&D intensity and firm performance. This approach acknowledges the insights provided by previous research and builds upon them to deliver a contextually relevant exploration that can guide future policy decisions, corporate strategies, and academic inquiries in this vital economic area.

4.4 Model Variables

To evaluate business performance, ROA and ROE were used since they are key financial ratios widely used to assess performance and profitability (Vithessonthi and Racela, 2016). ROA measures how efficiently a company uses its total assets to generate profits, whereas ROE assesses the profitability of shareholders' investments and the impact of capital structure. ROA serves as an indicator of asset utilization, reflecting the company's ability to generate earnings from its asset base. A higher ROA implies better asset utilization and operational efficiency. However, ROE provides information about the profitability of

shareholders' investments. It assesses shareholder returns by comparing net income to average shareholder equity. ROE considers the impact of debt financing and equity investments, allowing for an assessment of the company's ability to generate returns on the funds invested by shareholders.

In this study, the authors measure efficiency by using Tobin's Q as a proxy of market value, which serves as a dependent variable (See appendix 2 for variable definitions). According to Chen and Ibhagui (2019), Tobin's Q is considered a simple and accurate measure that provides valuable insights into a company's financial situation . By employing Tobin's Q as a standardized ratio measurement of performance, the researchers avoid the scale biases that can be present in other methods like market value added (MVA). When the capital market is well-developed and fully efficient, Tobin's Q becomes an ideal measure of a company's value. However, the current capital market may not be perfectly efficient, leading to some disparities between its effectiveness and that of a completely efficient market. Overall, this study utilizes Tobin's Q similar to Chen & Ibhagui (2019), as a reliable and informative measure to assess efficiency and gain valuable insights into the financial performance of companies.

$$\textbf{\textit{Tobin's Q}} = \frac{MVE + PS + DEBT}{TA}$$

MVE = Firm's Share Price × Number of Common Stock

PS = Liquidating Value of Outstanding Preferred Stock

DEBT = Current Liabilities-Current Asset + Book Value of Long Term Debt

TA = Total Assets

The debt ratio, which is determined by dividing total debt by total assets, sheds light on the degree of financial leverage and risk exposure a company is exposed to. By including the debt ratio as a control variable, we hope to assess the impact of a firm's capital structure on its financial performance. A higher debt ratio may indicate higher financial risk, as increased levels of debt may result in higher interest expenses and financial obligations. Examining the relationship between the debt ratio and the dependent variables allows us to evaluate the potential impact of financial leverage on firm profitability.

The size of a firm, as measured by the log of total assets, represents its scale and resources. Including size as an independent variable allows us to account for the potential influence of firm size on firm performance. Larger firms may benefit from economies of scale, a broader market presence, and greater access to resources, which could positively impact their profitability. By examining the relationship between firm size and the dependent variables, we can assess whether larger firms tend to achieve higher returns on assets and equity.

The choice of independent variables in the regression models is consistent with prior research that has identified these factors as important drivers of firm performance (Chen, et al., 2019). For example, studies have found a positive relationship between R&D intensity and firm performance, suggesting that firms that invest more in R&D are more likely to achieve higher levels of growth and profitability (e.g., Hitt et al., 1997). Similarly, studies have found that measures of financial performance such as ROA, ROE, revenue, and net income are positively associated with firm performance (e.g., Demirgüç-Kunt and Maksimovic, 1998). The inclusion of size as an independent variable is also consistent with prior research, which has found that larger firms tend to have different performance characteristics than smaller firms (e.g., Ahuja and Lampert, 2001). Overall, by selecting variables that have been shown to be important drivers of firm performance in prior research, the analysis can provide valuable insights into the factors that contribute to a firm's success.

4.5 Regression Models

When examining panel data, fixed effects models are especially helpful because they account for unobserved time-invariant heterogeneity among individuals. This indicates that rather than estimating the effects of differences across individuals at a single point in time, the model estimates the effects of changes within individuals over time. This aids in addressing the endogeneity and bias caused by omitted variables that are frequently present in cross-sectional analyses (Allison, 2009).

In this study, four different regression models were used. The first regression model aims to find out if firm performance affects R&D spending. In this model R&D intensity is our dependent variable, as for the independent variables we use ROA, ROE and Tobin’s Q. Size (log of Total Assets) and leverage (Total Debt / Total Assets) are our control variables

taking into account the size of the companies and the leverage level and how these affect our results.

Model 1: Exploring How firm performance affects R&D Intensity

R&D Intensity {it} = β0 + β1 ROA {it} + β2 ROE {it} + β3 Tobin's Q {it} + β4 Size {it} + β5 Leverage {it} + u {it}

Models 2 to 4: How R&D intensity affects firm performance

Firm performance (ROA, ROE, Tobin's Q) {it} = β0 + β1 R&D Intensity {it} + β2 R&D Intensity squared {it} + β3 Size {it} + β4 Leverage {it} + u{it}

Where in all of the models R&D intensity {it} is the variable representing the R&D intensity for firm *i* in year *t*. β's are the coefficients of the selected independent variables. U{it} being our error term. To investigate the relationships between the dependent variables (ROA, ROE, Tobin's Q) and the primary independent variable, R&D intensity, along with control variables (leverage and firm size), we employ a fixed effects regression model. This approach helps in isolating the within-firm effects over time.

The fixed effects model was estimated using ordinary least squares (OLS) with robust standard errors, clustered at the firm level. This clustering corrects for potential heteroskedasticity and intra-group correlation within firms, ensuring reliable inference. To explore the potential non-linear, diminishing effects of R&D intensity, we include the squared term of R&D intensity in the model. This allows the model to capture any U-shaped or diminishing relationship between R&D intensity and the dependent variables.

The fixed effects regression methodology employed in this study provides a robust framework for analyzing the dynamic relationships between R&D intensity and key performance indicators at the firm level. By controlling for unobserved, time-invariant firm characteristics and utilizing robust standard errors, the methodology offers valuable insights into the complex interplay between innovation, financial structure, and firm performance. Future research may extend this analysis to different contexts or explore additional moderating and mediating variables.

5 Empirical Findings

This section presents the empirical findings regarding the relationship between R&D intensity and firm performance in the Nordic countries. The analysis includes four models: Model 1, where the dependent variable is R&D intensity and Models 2 to 4, where measures of firm performance are used as the dependent variable. The findings will also include descriptive statistics of the data used in the study and a correlation table of the variables.

5.1 Descriptive Statistics

The tables below summarize all of the variables and raw values used in this study. Table 1 shows the raw values and Table 2 shows us the actual values used in the regression models. The original dataset consists of several financial variables, with "size" having a mean of 8.224 and ranging from 1.798 to 13.352, "leverage" with a mean of 0.211 and values from 0 to 1.427, "ROA" with a mean of 0.076 and ranging from -0.781 to 2.501, "ROE" with a mean of 0.161 and ranging from -1.473 to 3.859, "Tobin's Q" with a mean of 2.553 and ranging from -0.729 to 42.718, and "RD Intensity" with a mean of 0.133 and ranging from 0 to 25.018.

To minimize the influence of outliers, all variables except "size" were winsorized at the 1st and 99th percentiles. The resulting statistics reveal a considerable reduction in the range of values and slight changes in the mean and standard deviation. Specifically, "leverage" was transformed to a mean of 0.208 and a range from 0 to 0.6; "ROA" to a mean of 0.074 and range from -0.305 to 0.367; "ROE" to a mean of 0.156 and range from -0.514 to 0.765; "Tobin's Q" to a mean of 2.45 and range from -0.181 to 16.238; and "RD Intensity" to a mean of 0.071 and range from 0 to 1.171.

The winsorized data showed significant differences from the original data, reflecting the elimination of extreme values. This is most pronounced in variables such as Leverage, Tobin's Q, and RD intensity. The decision to winsorize the data can be justified by its contribution to greater robustness in statistical estimates, alignment with common statistical assumptions like normality, and preservation of the overall structure of the data.

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
TotalRevnue	*1042*	*17128.189*	*47179.207*	*.881*	*473479*
NetIncome	*1042*	*1528.29*	*6558.23*	*-22993*	*141828*
RDexp	*1042*	*757.955*	*2539.867*	*.017*	*23287*
MarketCap	*1042*	*31963.949*	*117523.76*	*0*	*2127262.1*
TotalLiabilities	*1042*	*14365.323*	*42567.767*	*.915*	*462828*
TotalAssets	*1042*	*23449.667*	*61589.775*	*6.039*	*629064*
ROA	*1042*	*.076*	*.125*	*-.781*	*2.501*
ROE	*1042*	*.161*	*.237*	*-1.473*	*3.859*
TobinsQ	*1042*	*2.553*	*3.621*	*-.729*	*42.718*
RDintensity	*1042*	*.133*	*1.004*	*0*	*25.018*
size	*1042*	*8.224*	*2.059*	*1.798*	*13.352*
Leverage	*1042*	*.211*	*.14*	*0*	*1.427*

Table 1 *Raw Summary Statistics*

Table 1 shows all of the raw values of variables and ratios used. In order to reduce the impact of extreme values, all of the variables except size were winsorized at 1st and 99th percentiles. This can be seen in Table 2, where the values used in the actual regression model are represented.

Variable	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
size	*1042*	*8.224*	*2.059*	*1.798*	*13.352*
Leverage win	*1042*	*.208*	*.128*	*0*	*.6*
ROA win	*1042*	*.074*	*.085*	*-.305*	*.367*
ROE win	*1042*	*.156*	*.166*	*-.514*	*.765*
TobinsQ win	*1042*	*2.45*	*2.923*	*-.181*	*16.238*
RDintensity win	*1042*	*.071*	*.149*	*0*	*1.171*

Table 2 *Refined Summary Statistics*

5.2 Correlation

Table 3 displays the pairwise correlations of the study's variables, providing initial insights into their relationships. Most notably, R&D Intensity (RDintensity_win) is negatively correlated with both ROA_win and ROE_win at statistically significant levels. This suggests that firms with higher R&D intensity relative to their assets might have lower returns on assets and equity. Conversely, RDintensity_win exhibits a positive and statistically significant correlation with Tobin's Q (TobinsQ_win), indicating that firms with greater investment in R&D are generally more highly valued in the market relative to their book values.

The negative correlation between RDintensity_win and size might imply that larger firms tend to have lower R&D intensity, possibly reflecting a different strategic focus or diversification. The relationships between ROA_win, ROE_win, and Tobin's Q are positively correlated, reflecting the intuitive link between profitability and market valuation.

Leverage (Leverage_win) is negatively correlated with ROA_win, ROE_win, and TobinsQ_win, which may suggest that higher levels of debt relative to assets are associated with lower profitability and market valuation. Interestingly, the correlation between size and Tobin's Q is negative, hinting that larger firms may have lower market valuations

relative to their book values. The positive correlation between size and Leverage_win could indicate that larger firms tend to operate with more debt relative to their assets. These correlations, though statistically significant, do not provide causative relationships but offer valuable insights that warrant further investigation. The absence of any extremely high correlations between the independent variables suggests that multicollinearity might not be a substantial concern in the subsequent regression analysis.

Variables	(1)	(2)	(3)	(4)	(5)	(6)
(1) RDintensity_win	1.000					
(2) ROA_win	-0.291*	1.000				
(3) ROE_win	-0.178*	0.839*	1.000			
(4) TobinsQ_win	0.153*	0.531*	0.410*	1.000		
(5) size	-0.248*	-0.122*	-0.064*	-0.384*	1.000	
(6) Leverage_win	-0.084*	-0.349*	-0.186*	-0.282*	0.177*	1.000

** p<0.05*

Table 3 *Pairwise Correlation Table Between the Variables*

5.3 Regression Results

The regression results of Model 1 (See Table 4) show the relationship between R&D intensity and several key financial metrics reveals a complex picture. The fixed effects regression model presented examines the relationship between firm performance and R&D intensity across 1042 observations. Five variables representing different aspects of firm performance were studied: ROA, ROE, Tobin's Q, Leverage, and Size. Economically, the negative coefficient for ROA (-0.918, $p < 0.05$) implies that firms with higher profitability might invest less in R&D, possibly reflecting a focus on consolidating existing gains rather than pursuing innovation. Conversely, the positive coefficient for ROE (0.369, $p < 0.1$) suggests that firms with higher equity returns might be more growth-oriented, leading to increased investment in R&D.

The relationship between Tobin's Q and R&D intensity is positive but marginal (0.005, p <

0.1), perhaps reflecting a nuanced perception within the market that R&D investment is valuable but not strongly so. Leverage does not appear to significantly influence R&D intensity (0.083, p = 0.161), indicating that the way a firm is financed might not play a pivotal role in its investment in R&D. The negative coefficient for firm size (-0.028, p < 0.01) could suggest that larger firms invest relatively less in R&D, possibly because of economies of scale or risk aversion. The results provide mixed evidence about the relationship between firm performance indicators and R&D intensity. While some variables show statistically significant relationships, the interpretation of these relationships requires careful consideration of the specific industry context and underlying economic logic. The findings highlight the complexity of decision-making around R&D investment and offer a valuable perspective for both academics and practitioners interested in understanding how firms strategically allocate resources towards innovation.

RDintensity_win	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
ROA_win	-.918	.444	-2.07	.041	-1.798	-.039	**
ROE_win	.369	.208	1.77	.079	-.043	.782	*
TobinsQ_win	.005	.003	1.74	.085	-.001	.011	*
Leverage_win	.083	.059	1.41	.161	-.033	.198	
size	-.028	.01	-2.86	.005	-.048	-.009	***
Constant	.284	.07	4.04	0	.145	.424	***

Mean dependent var	0.071	SD dependent var	0.149
R-squared	0.400	Number of obs	1042
F-test	2.009	Prob > F	0.098
Akaike crit. (AIC)	-3651.312	Bayesian crit. (BIC)	-3626.568

*** p<.01, ** p<.05, * p<.1

Table 4 *Model 1 Regression Results*

The results in Table 5 present some interesting insights into the relationships between R&D Intensity and firm performance.

In Model 2, the coefficient of -0.997 for R&D intensity ($p < 0.05$) indicates a statistically significant negative relationship with ROA. Economically, this suggests that an increase in R&D intensity is associated with a decrease in ROA. This might imply that a focus on R&D may not immediately translate into higher profitability from assets. Similarly, Model 3 reveals a significant negative relationship with ROE, suggesting that greater R&D intensity is related to lower equity returns. The negative coefficient for R&D intensity in Model 4 with Tobin's Q, though not statistically significant, could imply that market valuation relative to book value is not enhanced by increased R&D intensity.

The positive and significant coefficients for the square of R&D Intensity (RDintensity_squared) in Models 2 and 3 might suggest a diminishing negative or even positive effect of R&D intensity at higher levels, capturing a potential non-linear effect. In terms of leverage (Leverage_win), the negative and significant coefficients across all three models indicate that higher leverage is consistently associated with lower ROA, ROE, and Tobin's Q. This could be an indicator of increased financial risk affecting both profitability and valuation. Additionally, in Model 4, the positive and significant coefficient with Tobin's Q for size suggests that larger firms are more highly valued by the market relative to their book values.

The inclusion of Year controls and Company fixed effects, along with clustered standard errors, enhances the robustness of these models. R-squared values indicate that these models explain a reasonable, though not substantial, proportion of the variability in the dependent variables. The negative relationship between R&D intensity and profitability might align with literature highlighting the long-term and uncertain nature of R&D investments. The non-linear effect captured by RDintensity_squared could resonate with research suggesting an optimal level of R&D investment.

	Model 2	Model 3	Model 4
VARIABLES	ROA_win	ROE_win	TobinsQ_win
RDintensity_win	-0.997**	-1.999***	-14.46
	(0.405)	(0.742)	(17.95)
RDintensity_squared	0.677*	1.987***	15.45
	(0.342)	(0.697)	(15.29)
Leverage_win	-0.200***	-0.296***	-3.229***
	(0.0288)	(0.0709)	(1.150)
size	-0.00598	-0.00817	0.961**
	(0.00679)	(0.0122)	(0.464)
Constant	0.218***	0.373***	-4.169
	(0.0543)	(0.113)	(3.878)
Year controls	Yes	Yes	Yes
Company fixed effects	Yes	Yes	Yes
Standard errors	Clustered	Clustered	Clustered
Observations	1,042	1,042	1,042
R-squared	0.197	0.100	0.092
Number of CompanyID	120	120	120
Robust standard errors in parentheses			

*** p<0.01, ** p<0.05, * p<0.1

Table 5 *Regression Models 2-4*

Based on the results, the next step is to analyze the formulated hypothesis:

Hypothesis 1:

Null Hypothesis (H01): There is no significant relationship between R&D intensity and firm performance among large-cap firms in the Nordic region.

Alternative Hypothesis (HA1): There is a significant positive relationship between R&D intensity and firm performance among large-cap firms in the Nordic region.

The regression results shown in Table 4 suggest that there is some complexity in the relationship between R&D intensity and firm performance, and the coefficients for different firm performance variables illustrate mixed results. For instance, the negative coefficient for ROA suggests that firms with higher earnings might allocate less in R&D, while the positive coefficient for ROE implies that firms with higher equity returns might invest more in R&D. The coefficient for Tobin's Q is positive, but only marginally significant. This implies that R&D intensity may not strongly affect market valuation. These results do not completely support HA1 of a significant positive relationship between R&D intensity and firm performance. Furthermore, H01 is also not supported by the regression results. This would suggest a more multifaceted relationship between variables than originally hypothesized.

Hypothesis 2:

Null Hypothesis (H02): There are no diminishing effects between R&D intensity and firm performance.

Alternative Hypothesis (HA2): There are diminishing effects between R&D intensity and firm performance.

The inclusion of the squared term for R&D intensity in models 2 and 3 provides information on the potential non-linear effect of R&D intensity on firm performance. The positive and statistically significant coefficients for the squared term suggest that there indeed are diminishing effects as R&D intensity increases. This discovery aligns with the idea that there might be an optimal level of R&D investment beyond which the returns diminish, as suggested by Chen & Ibhagui (2019). The presence of non-linear effects further complicates the picture because it implies that there might be a level of R&D intensity beyond which the benefits decrease.

6 Discussion & Analysis

Based on the results obtained, the next step of the paper will focus on discussing and analyzing the results to address the research question:

What is the relationship between R&D intensity and firm performance within large-cap firms in the Nordic region?

It is essential to analyze both the statistical and economic significance of the relationship between R&D intensity and firm performance. While statistical significance is determined by the raw values of statistical results, which indicate the likelihood of observing outcomes by chance, economic significance expands by seeking the pragmatic meaningfulness of these outcomes. The authors investigate whether the relationships found are caused by real effects or just randomness because the significance suggested by p-values prompts questions of causation. However, the economic significance of this relationship is what drives our study.

The coefficients pertaining to ROA, ROE, and Tobin's Q hint at connections between R&D intensity and firm performance, yet they do not consistently present a robust economic magnitude. This nuance emphasizes the idea that, although relationships exist, their real-world impact on significant changes in firm performance may be limited. However, one important economic significance could be that while firms with higher profitability may invest less in R&D, possibly reflecting a focus on existing gains over innovation, those with higher ROE might be more inclined towards growth and thus invest more in R&D. In addition, the non-linear effect discovered might imply that there could be an optimal level of R&D intensity, which reflects the long-term and uncertain nature of R&D (Vithessonthi & Racela, 2016).

Trying to find the answer for the research question, the authors discovered that numerous studies have illustrated a positive association between R&D intensity and various aspects of financial performance (Connolly & Hirschey, 2005; Gunday et al., 2011; Kafouros et al., 2008; Vithessonthi & Racela, 2016). For example, Kafouros et al. (2008) found that R&D

intensity positively affects a firm's sales growth and market value. Similarly, Gunday et al. (2011) reported that R&D intensity is connected to improved market share and ROA. However, as this study's results suggest, the relationship is far from simple. The nuanced results, especially the mixed coefficients for various firm performance measures, such as ROA and Tobin's Q, challenge the notion of a consistent and linear positive relationship hypothesized in this study. Notably, these results somewhat align with the findings of Brouthers et al. (2005), Chen et al. (2019), and Czarnitzki and Kraft (2009), who pointed out the complexity of the correlation between R&D intensity and firm performance.

The finding of a non-linear relationship between R&D intensity and firm performance (Chen & Ibhagui, 2019) resonates with the findings of this paper. The squared term for R&D intensity included in regression models 2 and 3 highlights the possibility of diminishing effects at higher R&D investment levels. This supports the findings of Chen & Ibhagui (2019), who found an inverted U-shaped relationship, where the positive impact of R&D intensity diminishes after reaching a particular threshold. Furthermore, the existence of mutual influences indicates that the relationship is not one-way but rather is one of mutual causation. There may be one or more thresholds for the non-linear effect of R&D expenditure on profitability. When the firm's R&D intensity is below the threshold, increasing R&D intensity can significantly improve the performance of the firm. However, when the R&D intensity is above the threshold, the promotion may be diminished, and the firm’s profitability may even be affected.

The Nordic countries are known for their strong innovation capabilities, and the research on the relationship between R&D intensity and firm performance in the Nordic region presents a unique perspective due to the specific economic and industrial characteristics these countries share. While previous studies have predominantly focused on individual Nordic countries, this study of the relationship across the entire Nordic region offered a more holistic understanding of this dynamic. Previous literature in the Nordic context has indeed suggested a positive correlation between R&D investment and firm performance. However, as mentioned, the findings of this paper introduce a level of complexity that challenges the straightforward positive relationship. For instance, the observed negative ROA coefficient may reflect the impact of other variables on the profitability of firms with higher R&D intensity. The homogeneous socio-economic factors in the region may contribute to the intricate patterns discovered in the study. The value of taking the regional context into account is highlighted by this nuanced understanding.

The findings offer the Nordic region both opportunities and challenges. The authors believe that the decreased investment in R&D by larger firms might indicate a risk-averse culture that could limit innovation. On the other hand, the existence of diminishing returns to R&D suggests an opportunity for more strategic R&D planning, which could lead to optimal levels of investment. The authors speculate that due to the complex dynamics of the Nordic region, the need for careful strategic management of R&D intensity to maintain innovation is essential.

To sum it up, the mixed results could be attributed to underlying risk aversion, the long-term nature of R&D investments, and the unique nature of corporate cultures within the Nordic region. To answer the research question, this study reveals that the relationship between R&D intensity and firm performance within large-cap firms in the Nordic region is multifaceted. Firstly, the study illustrates that an increase in R&D intensity is associated with a decrease in ROA, which implies that higher R&D intensity may not lead to immediate gains. In contrast, firms with a higher ROE may invest more in R&D, indicating a progressive approach. The study also reveals diminishing effects at higher levels of R&D intensity, which points to an optimal level of R&D investment after which returns decrease. Additionally, the relationship between R&D intensity and market valuation (Tobin's Q) is found to be positive but marginal. Finally, it is interesting to note that the larger the firm, the less it seems to invest in R&D.

7 Conclusion

In conclusion, this thesis has examined the complex relationship between R&D intensity and firm performance in the Nordic countries. Through panel data analysis and regression modeling, we have provided valuable insights into the innovation landscape within the Nordic region.

This study used R&D intensity to measure innovation. We discovered that spending more on R&D does not always lead to immediate financial success, as measured by return on assets (ROA). However, firms with higher return on equity (ROE) seem more willing to spend on R&D, possibly indicating a focus on long-term growth. We also found that after a certain point, spending more on R&D doesn't always bring more benefits, meaning there might be an ideal amount to spend. One of the interesting things we found is that the relationship between R&D and firm performance goes both ways. This two-way relationship means that while spending on R&D can influence a company's success, how well the firm is doing can also affect how much it spends on R&D. For example, a firm doing well might choose to invest more in R&D to continue growing, while a firm that isn't performing as strongly might cut back on R&D expenses.

The literature review illuminated a substantial body of work indicating a positive correlation between R&D intensity and various aspects of financial performance. However, the empirical findings presented in this study introduce a layer of nuance that challenges the prevailing notion of a linear positive relationship. The mixed coefficients associated with different firm performance indicators suggest a complex interplay, with variables such as ROA and Tobin's Q reflecting a lack of consistent alignment with expectations.

In the end, this study shows that the relationship between R&D spending and firm performance in large Nordic companies is complicated and affected by many factors. It's not just about spending more on R&D to perform better; it's about understanding how R&D and performance interact with each other and finding the right balance. The findings here could help businesses and policymakers in the Nordic region make more informed decisions about R&D investment, considering both the potential rewards and the complexities of this relationship. Future research might explore this relationship in more

detail and across different industries, to build an even clearer picture of how R&D and performance interact in the business world.

7.1 Limitations & Suggestions

While this study provides valuable insights, it is not without limitations. The use of panel data from the Nordic countries restricts the generalizability of the findings to other contexts. Future research could expand the geographical scope and incorporate additional variables to capture the multidimensional nature of firm performance such as the effect of governmental ownership in the context of firm performance and R&D. There is also the matter of the COVID-19 pandemic possibly affecting our results, since it could be that during 2020 and 2021 firms would stock up on excess cash as a form of risk management instead of investing it in R&D. This is only the author's own reasoning, and there is no evidence to support or deny this theory. This is a matter that could be looked at in future studies as well.

It is important to note that the findings of this thesis contribute to the existing body of knowledge by providing valuable empirical evidence within the specific context of the Nordic countries. These results call for a re-evaluation of the prevailing assumptions and highlight the need for a nuanced approach to R&D and innovation strategies. Policymakers should consider the long-term implications of R&D investments, recognizing the potential lagged effects on firm performance. Moreover, fostering a supportive innovation ecosystem that nurtures creativity and collaboration remains crucial.

Future R&D strategies can benefit from a more nuanced and balanced approach, focusing on optimal levels that maximize benefits without taking too much away from short-term profits. In order to promote innovation and long-term growth, the trends may also encourage Nordic governments and regulators to mandate or encourage R&D investments, particularly in larger, more conservative firms.

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Appendix

Hausman (1978) specification test	
	Coef.
Chi-square test value	146.028
P-value	0

Appendix 1 *Hausman test*

Note: To determine fixed effects regression. Hausman test for regression (1). As the p-value is below 0,05, it is concluded that fixed effects are preferred over random effects.

Appendix 2 Variable Definitions

Variable type	**Variable name**	**Variable explanation**
dependent variable	ROA	Return on Assets
	ROE	Return on Equity
	Tobins Q	(MV+PS+Debt) / TA
Independent variable	R&D intensity	R&D Exp. / Revenue
Interaction term	R&D intensity squared	(R&D intensity)^2
Control variable	Debt ratio	Total debt / Total Assets
	Size	Log of Total Assets

Appendix 2 *Variable Definitions*

Note: More accurate descriptions of the variables are given in the text.