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R&D's impact on stock returns in the biotechnology industry in the Nordic countries

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Abstract

This is a study on the impact of R&D expenditure, expressed in the form of R&D intensity, on stock returns in the Nordic Biotechnology sector. Firms in this sector are generally R&D intensive and the geographic area of the Nordic countries is known for being highly innovative. For the sample, 36 firms are analyzed through the period of 2013 - 2022. The empirical results show that R&D intensity has a statistically significant but small negative effect on the total returns of stocks. The results of this study stand in contrast to previous literature showing a positive relationship between R&D intensity and stock returns. The results are aligned with that strand of previous literature arguing that no significant relationship between R&D and stock returns exists.

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1. Introduction

Research & Development (R&D) is a term that refers to activities that a company takes part in with the aim of creating new products and services, as well as improving current ones. It plays a key role in shaping the future by driving innovation, productivity, and economic growth. Without money going into advancing the product or service, companies may find it hard to be competitive in the long run.

Different business sectors have different dependence on R&D expenditures and according to data from the European Commission's EU Industrial R&D Scoreboard, the Technology sector as a whole is the most R&D intensive. R&D intensity is a measurement that is often used in these types of reports which puts R&D expenditure in relation to net sales.
In the EU Industrial R&D Scoreboard of 2020, data from 2019 based on 2500 companies worldwide that invests the most into R&D ranks Pharmaceuticals & Biotechnology (15,4%) as the most R&D intensive with other sectors such as Software & Computer services (11,8%) and Technology hardware & Equipment (9,0%) following not too far behind. To put this in perspective, the Bank sector came in at 3,2% and Oil & Gas at 0,4% that same year. Furthermore, the EU Industrial R&D Scoreboard shows that the Health industry in its entirety was responsible for 20,5% of total global R&D investments in 2019.

Judging from this data and the scoreboard's results from previous years which showed similar findings, it becomes evident that in these Technology sectors - R&D is highly prioritized. This is perhaps to no surprise since companies operating in aforementioned industries are constantly competing to be first with the new big discovery.

Found on the next page is a representation retrieved from the scoreboard of 2021 which depicts R&D investment share by sector group in the EU in 2020. The reason for the 2020 scoreboard being cited earlier is because in that year's edition, sectors were given a further breakdown in the appendix chapters - providing data for Biotechnology & Pharmaceuticals which is not done in later editions where only the term "Health industries" is used. It is defined as Biotechnology, Health Providers, Medical Equipment, Medical Supplies and lastly Pharmaceuticals. Grouping Biotechnology & Pharmaceuticals together is not unique for the EU Commission. Bloomberg and other similar companies often talk about Biotechnology and Pharmaceuticals together because of the high collaboration between the two industries. Due to this overlap, these two will be analyzed in this study as one sector. While both industries produce medicines, the difference is that in Biotechnology, they are based on living organisms and in Pharmaceuticals they have a chemical base. As seen below, Health industries in the EU in 2020 stood for nearly 20% of total R&D investments in the region. That same year, the figure was 27,2% in the US, 6,1% in China and 20,8% globally. Again, it can be seen that R&D is taken seriously in the Health industries.

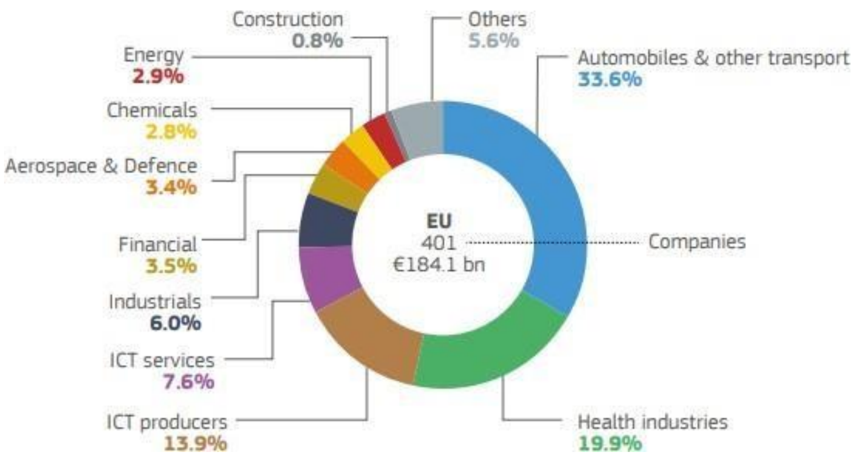


Figure 1. 2021 EU Industrial R&D Investment Scoreboard – Share of R&D Investment in 2020 by Region/Country and Sector Group

Biotechnology is an industry that has gained a lot of interest, popularity, and funding during recent years. Technology as a whole is a big and fast-moving industry and biotechnology is no exception. It is ever-changing and must constantly adapt to recent events. Dr. Matthew Partridge expands on this in the article “How Covid-19 changed Biotechnology - and how you can invest”, where he states that the pandemic has transformed and accelerated scientific Research & Development which will greatly benefit Healthcare. Although the crisis has led to immense negative consequences around the world, this may be one of the few upsides to it. Furthermore, the article features Linden Thomson and Cinney Zhang who are responsible for the Biotechnology strategy at AXA Investment Management and they claim that even before Covid-19, there were big advances being made in the industry - using the word “extraordinary” when describing the recent innovations and growth. Lastly, it reads that the huge surge in funding and incorporation of machine learning and artificial intelligence is expected to keep delivering long-term benefits to the field.

This observation is further reinforced by the EU Industrial R&D Scoreboard which, under their "Key Technological Trends"-chapter, states that biotechnology is a rapidly growing industry that has benefited from the recent Covid-19 pandemic. It is expected to keep making promising progress and the range of applications to become even wider. The increased activity has led to the development of a vaccine taking under a year, while a project of that kind normally takes between 6 and 10 years.

But what exactly is biotechnology?

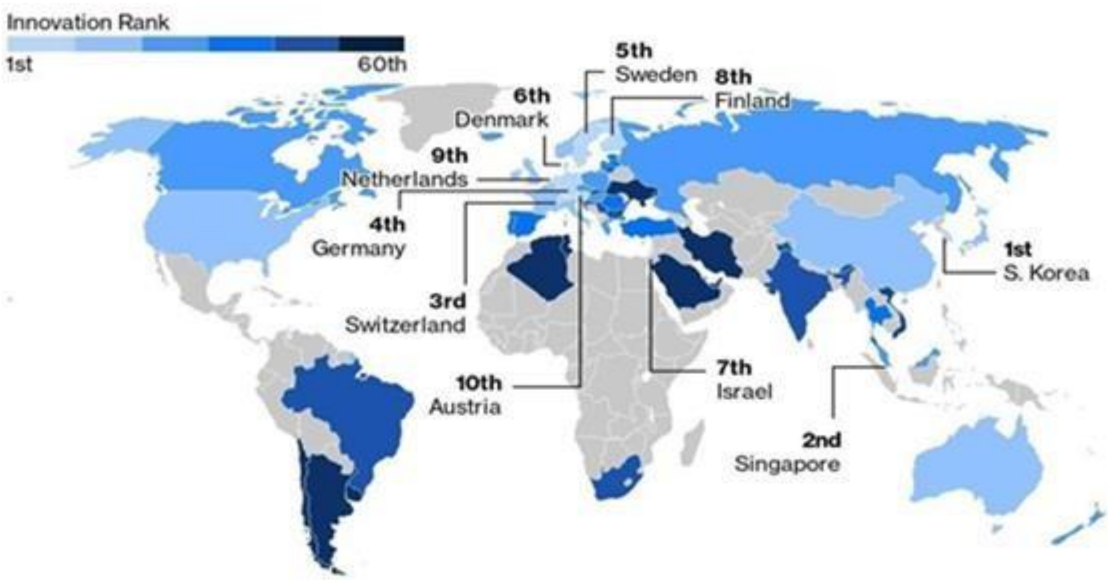
Biotechnology is a wide term and may therefore be a bit hard to define. According to Britannica, Biotechnology is "the use of biology to solve problems and make useful products" and it also reads that the most prominent area today is genetic engineering which aids in production of therapeutic proteins and drugs. It is about understanding the function of living organisms on a molecular level, and thus encompasses disciplines such as biology, chemistry, physics and mathematics. People have been using Biotechnology for thousands of years - making bread, alcohol and cheese for example. Calling this Biotechnology might be unintuitive and not what people think of it today but according to the definition, it is. The term became popularized in the 60's and 70's when Biotechnology as an industry started to emerge. In 1980, the U.S Supreme Court ruled that a human made living micro-organism can be patentable, which resulted in the young industry's first boom. Ever since, the term and applications have widened through the years and with every discovery. Today's applications of Biotechnology are primarily within medicine, agriculture, and food industries. Environmental cleanup is also a big task in the industry where biological enzymes are being produced that can digest contaminants into nontoxic chemicals.

As previously mentioned, it is stated in the EU Industrial Scoreboard that Biotechnology's future looks bright with important advances being made in multi-disciplinary areas like biophysics and bioelectronics - merging software technology such as AI with biology.

When discussing Biotechnology, it is hard to avoid including the Nordic countries in the conversation. More specifically - Sweden, Denmark and Finland. According to the Bloomberg Innovation Index for 2021, all of these were in the top 10 most innovative countries in the world - ranking Sweden 5th, Denmark 6th and Finland 8th while South Korea got 1st place. The national R&D intensity metric, which measures the R&D expenditure as a percentage of GDP, was also impressive with the countries coming in at 4th, 8th and 11th place, respectively. McKinsey's Biotechnology innovation-index and Yali Friedman's equivalent, Ph.D. and author in Biotechnology, both hold Europe and the Nordic countries in high regard.

Found below is an illustration of the Bloomberg Innovation Index of 2021. A lighter color indicates increased level of innovation. As can be seen here, many countries in Europe are highly innovative.

World's 60 Most Innovative Economies
South Korea, Singapore and Switzerland lead the index 2021



Sources: Bloomberg, International Labor Organization, International Monetary Fund, World Bank, Organization for Economic Cooperation and Development, World Intellectual Property Organization, United Nations Educational, Scientific and Cultural Organization

Figure 2. Graphic illustration of the Bloomberg Index of 2021

2. Purpose & Research Questions

Assuming that products are advancing as a result of R&D and seeing as companies within the Biotechnology & Pharmaceutical industry invest a lot in these activities, the question that may arise is whether this money actually translates to an increase in stock returns - or in other words, whether stock price include the value of R&D investments.

The aim of the study is to test if firm R&D intensity, measured by R&D expenditures/net sales, has an effect on stock returns. The purpose relates to Eugene Fama's (1970) theory that efficient market prices fully reflect all available information. This would in this case be focused on R&D information in the context of the Nordic Biotechnology Industry. Studying R&D expenditures with stock returns is nothing new, but for the industry in this region – the literature is lacking.

The study will aim to answer the following question,
Does R&D expenditure-to-net sales (firm R&D intensity) and stock returns in the Nordic Biotechnology industry share a relationship? And if so, what is the nature and magnitude of this relationship?

2.1. Limitations of the study

The biggest limitation of the study has been the challenge of finding sufficient data. The majority of Bloomberg's data for Nordic Biotechnology companies was found to be insufficient. Either data for some variables were missing, all data were missing, or the company had not existed throughout the full period of analysis. For us to find the data sufficient and usable, it has to be close to complete for all variables of interest during the entire period.
In some countries analyzed, it is not compulsory to report R&D expenditures which further affected the sample. Furthermore, firms that do report it may do so differently, with some expensing it immediately and some not, for example. Another thing worth noting is that by nature of R&D - benefits may not materialize until much later on. This means that for the period chosen in this analysis, some R&D related future benefits may be left out.
Lastly, R&D being reported quarterly while other variables being reported daily is something which cannot be controlled.

3. Theoretical framework

3.1. Accounting standards for R&D

R&D expenditures are an important aspect for companies in certain industries and they are usually reported in the company's financial statements. According to the international accounting standard IAS 38 (IFRS) there are several requirements that must be met in order for the company to include R&D expenditures as intangible assets.

The standard makes a distinction between research and development. Research is the process of systematically seeking knowledge and insight while development is the process of implementing the knowledge gathered from the research to come up with new products, services or systems that will be used commercially later on.

According to IAS 38, all costs that originate from the research phase cannot be reported as assets in the balance sheet and they must be reported as costs in the income statement. This is due to the fact that companies cannot show that their research will likely lead to profit generation in the future. When it comes to the development process, the company can only report the outcome as an asset in the balance sheet if it meets a number of criteria defined in IAS.

It is also worth mentioning that accounting standards and their application may be slightly different in different countries and for different types of corporations. In practice, most companies will only have the option of taking up their R&D expenditures as costs in the income statement.

3.2. Information asymmetry

In the ideal scenario, markets are well-functioning and both buyers and sellers have full access to the same information. However, this is rarely the case in practice as many markets exhibit signs of asymmetrical information distribution. George A. Akerlof (1970) first introduced the concept of information asymmetry. The information asymmetry is found to be especially evident in high-tech industries. In their study, Himmelberg and Petersen describe that information asymmetry in small and high-tech firms makes R&D investments very hard for outsiders to value. Furthermore, there might exist an incentive for firms to actively try to keep this information asymmetry as shown by Himmelberg and Petersen (1994). Consequently, Aboody and Lev (2000) argue that gains from insider trading in R&D intensive firms are larger than in firms that do not engage in R&D activities.

Moral hazard and Adverse selection are consequences of information asymmetry and are prevalent in the context of high-tech investments that engage in R&D. These affect R&D firms by making it harder for them to acquire external financing. Since innovation is considered a risky activity, firms must rely on internal finance to raise the capital necessary to finance R&D. Kamien and Schwartz (1978).

3.3. The Efficient Market Hypothesis (EMH)

The efficient market hypothesis was developed by Eugene Fama (1970) where he describes it as a capital market equilibrium where all available information is fully reflected in the price. He adds that the efficient market hypothesis can be tested using assumptions divided into three categories; 1. A strong-form where all investors have full access to all relevant information, even insider information is reflected in the price. 2. A semi-strong-form where all publicly available information is available to investors and reflected in the price. Finally, 3. The weak-form uses historical information such as price and returns to test whether the market is efficient. R&D intensity would fall in the second category, as this information is publicly available for investors. Thus, R&D intensity should be reflected in the prices of stocks according to the semi-strong form of the efficient market hypothesis.

3.4. The Capital Asset Pricing Model (CAPM)

As explained in O'Sullivan (2018), the capital asset pricing model (CAPM) is fundamental to understanding the relationship between the expected return of an asset and its risk. The model was first introduced in 1964 by William Sharpe (1964). With the help of earlier work by Markowitz (1952) regarding risk preferences and other contributions such as Jack Treynor (1962), John Lintner (1965) and John Mossin (1966) - the earliest form of CAPM was created. Perold (2004) explains that CAPM revolves around the concept that not all risks affect prices of assets - if a risk can be avoided through diversification, it should not be considered a risk. The CAPM is a linear model that gives a prediction of the relationship between the risk and expected return of an asset. It is used to calculate the appropriate return for an asset given a certain level of risk.

In O'Sullivan (2018), he states that CAPM and the efficient market hypothesis are two central models in finance. Together, they create a standard framework and financing tool. In an efficient market, the price of a security should imitate the best possible estimation for its fundamental value. For the past 50 years, they have dominated financial economics. These two theories were for a long time together believed to accurately predict market prices of securities. This has been a topic of much discussion and research during recent decades, much due to the fact that CAPM has performed poorly in empirical tests. Another reason for criticism is that it relies on a set of assumptions that may not reflect reality. One assumption that has been particularly criticized is the one stating that all investors have the same expectations and thus make the same estimations for a security's future risk and return. Since both theories predict prices of securities based on this idea, their validity has been questioned - what happens when investors do not agree on expectations for the future? The assumption of rationality is also one that is often challenged, both in the context of CAPM and in the context of the EMH since CAPM to a large degree builds on the EMH. Investments in R&D usually have uncertain future outcomes, this uncertainty would affect the beta of the firms and thus investors will require a higher return for firms with high R&D intensity.

3.5. Carhart's four factor model and Fama's three factor model.

The three-factor model was developed by Kenneth French and Eugene Fama (1992) and it can be considered an extension of the CAPM introduced by Sharpe, Treynor and Lintner. The idea was to introduce more variables that would explain the difference in expected returns for different stocks. In addition to the beta value of the stock, two more variables that affected the returns were introduced. These are "SMB" i.e., the size premium and "HMB" i.e., the value premium.

The 4-factor model developed by Carhart (1997) demonstrates the market equilibrium taking four volatility factors into consideration. The coefficient of each factor shows the proportion of theexpected return that can be attributed to the four risk factors. The original four factor model developed by Mark Carhart is an extension to the three factors of Famas and French's model (1992) - the momentum factor is added. The momentum factor refers to the premium of stocks that performed well in the past period versus stocks that did not perform well. Carhart argues that the Fama and French's 3-factor model does not provide completely accurate explanations to the risk premium and is thus unreliable. The 4-factor model on the other hand ismore accurate and it reduces the pricing errors from using the CAPM or the three-factor model.

4. Literature review

In this literature review, a number of past studies that are related to the thesis problem will be presented. Over the years, studies have been done on the effect of R&D expenditure on market value. In Sougiannis (1994), he examines if firms' earnings are related to R&D and if it can be used to measure investment value of R&D. In the paper, it is mentioned that earlier research in the form of cross-sectional correlation analysis and regression done by Johnson (1967), Newman (1968) and Milburn (1971) found no significant link between R&D expenses and future returns. He explains these results by referring to the small sample sizes being used, econometrics techniques as well as quality of data for R&D. In his own study using cross-sectional data, results indicated that an increase in R&D expenditures lead to increased market value which implies that investors do in fact value R&D investments. Papers like Ben-Zion (1978), Griliches (1981), Hirschey (1982), Hirschey and Weygandt (1985), and Shevlin (1991) have also found evidence for a significant relationship between market value and R&D expenditures. These results have been used to make the claim that capitalization of R&D expenditures and amortization is a better approach than immediate expensing.

Lev and Sougiannis (1996) analyzed a large sample of public firms across many industries over the years 1975 – 1991, using cross-sectional regression with some interesting findings. Perhaps most relevant is the discovery of a significant intertemporal relationship between R&D capital and a firm's subsequent stock returns. As stated by the authors - "The estimated R&D capital does not appear to be fully reflected contemporaneously in stock prices, since R&D capital is associated with subsequent stock returns.", they believe this suggests 1. a mispricing of R&D intensive firms' shares (estimation showed 4,57% annually) which would be an underreaction to information about R&D, or 2. that these subsequent excess returns compensate for an extra market risk factor connected to R&D. Lastly, they conclude that these findings from the study suggest that R&D capitalization offers statistically reliable and economically important information which counters FASB 2, par. 41 which states - "A direct relationship between research and development costs and specific futurerevenue generally has not been demonstrated."

Chan et al. (2001) studied if the price of a stock fully incorporates the value of a firm's intangible assets, with an emphasis on R&D investments. The sample used was all US firms listed on the New York Stock Exchange (NYSE), American Stock Exchange (AMEX) and Nasdaq through the years 1975 - 1995. The results showed that average historical stock returns for firms that employ R&D activities are about the same as for firms that do not. In other words, the evidence did not find a direct link between R&D expenses and future stock returns and this aligns with their initial hypothesis which stated that stock prices value investor's unbiased expectations about the valuation of R&D. Furthermore, it appeared that a relationship between R&D intensity relative to sales and future returns was weak for firms doing R&D. Similar results were found when replacing R&D with advertising as the intangible asset. Lastly, the authors state that a big challenge they faced is finding reliable R&D expenditure data due to reasons such as accounting standards and difference in firms' way of categorizing and reporting R&D - putting a bit of uncertainty to the whole story.

Bloch (2003) examines the effect that R&D expenditures has on stock prices for Danish firms. For the sample, the entire Copenhagen Stock Exchange (CSE) was used, and the period was 1989 - 2001. With the use of panel data analysis and dividing up stocks into portfolios, the study aims to find out how R&D expenditures affects stock returns as well as to what extent the stock market values R&D intensive firms. Fundamental factors such as firm size and book-to-market ratio are also included. As for the results, they showed that R&D intensity has a very weak effect on stock returns when tested on its own - meaning that average returns for firms with high R&D expenditures are marginally higher than firms with no R&D. Though, when controlling for book-to-market ratio, the relationship between R&D and stock returns was strong. Firms with a high ratio, which could be interpreted as an indication of the security being underpriced, that are R&D intensive appear to bring greater future returns. Furthermore, there was weak evidence for the argument that R&D intensive firms are systematically undervalued in the market, or that risk premiums linked to these exist.

Franzen and Radhakrishnan (2009) analyzes the role of R&D expenditures across levels of firm profitability using the residual-income valuation model. With the evidence from Darrough and Ye (2007) showing that R&D expenses have a positive valuation multiplier for loss firms, they aim to find out if this applies to profit firms as well. Their analysis presented interesting results, showing that the valuation multiplier on R&D expenditures is expected to in fact be negative for profit firms - while coming to the same conclusion for loss firms as Darrough and Ye. They try to explain this by stating that a profit firm's earnings are more likely to contain information about R&D's future benefits than its counterpart which does not contain this information. This evidence aligns with their initial expectations for the two types of firms.

Nivoix and Ngunyen (2014) set out to answer a set of questions relating to the R&D expenditures of listed stocks in the Japanese stock market. The authors wanted to investigate how the stock market participants regard and value the investments made in R&D activities. In other words, does the level of R&D expenditures influence the firm's valuation? Furthermore, the study aims to investigate whether or not there is a significant difference in the level of R&D between different industries.

Data of all listed companies in the Tokyo Stock Exchange during the period of 1999 - 2006 is used. Instead of using the R&D magnitude as it is reported in the income statement of the firms, the authors chose to use R&D intensity as in many previously mentioned papers. The sample size studied is 641 firms and linear regression is used.

It was found that the R&D intensity did not change much over time between the period 1999 - 2006. However, there is considerable variation in the R&D intensity level between different industries and between different firms within an industry as well. It is also shown that firms who engage in R&D have higher stock returns. On the other hand, the authors failed to find a relationship between the level of R&D and the level of returns.

Jiang, Kose and Larsen (2020) investigated the relationship between R&D investment intensity and various components that make up stock price volatility. Quarterly data between 2003 - 2017 for a large sample of public firms in the Standard & Poor's 500 index was used. Multivariate regression analysis showed that stocks of firms with high R&D investment intensity have more total volatility but less jump volatility. This was explained through the argument of R&D intensive firms preferring higher stock liquidity and by displaying that these firms achieve this level of liquidity by frequently releasing information about R&D expenditures. Analytical techniques showed that firms with high R&D intensity choose to voluntarily disclose this information in many instances which results in higher stock liquidity and thus less jump volatility. This negative relationship proved to be clearer for firms with financial constraints, and this would make sense because these should have stronger incentives to release information about R&D in an attempt to increase stock liquidity.

Hou et al. (2021), as with previous literature mentioned, studies how R&D affects stock returns. The sample consisted of 21 countries/markets over the years 1981 - 2018 where data for stock returns and R&D are accessible and, in most countries, only firms listed in the largest stock exchanges are included. The results highlighted the important role of intangible investments in the pricing of assets, since it showed that R&D intensive firms generate higher subsequent stock returns in international equity markets. Combined with Chan et al. (2001) and Lev and Sougiannis's (1996, 1999) findings, this suggests the importance of intellectual capital in asset pricing. Furthermore, cross-country analysis found that country characteristics related to mispricing are irrelevant to the R&D effect. The researchers claim that the combined findings suggest R&D intensity as a predictor for stock returns to have more to do with innovation risk than with mispricing.

4.1. Hypotheses

Based on the existing literature related to the effects of R&D intensity and its effect on stock returns, two competing hypotheses are formulated:

H_0: There is no relationship between R&D intensity and total stock returns.

H_1: There is a relationship between R&D intensity and total stock returns.

5. Methodology and Data

This section outlines the methods used to perform the study. The section contains a description about the sample that will be studied and how the sample is chosen as well as how the data was retrieved. Furthermore, some descriptive statistics about the variables used in the regression models can be found. The regression models are defined and explained in this section with motivation provided for the reasoning behind including the different variables.

5.1. Data collection

The study is a quantitative study and thus empirical data is collected and analyzed to reach a conclusion. In the study, Biotechnology companies will be examined to see if there is a relationship between R&D intensity and stock returns. We construct our sample by selecting firms with their headquarters in one of the Nordic countries. We aim to include firms that operate within the Biotechnology sector or that have a significant proportion of their business activities relating to Biotechnology and closely related fields. To aid with this, the Bloomberg equity screening function is used to select the sample which uses criteria that fits our definition. The screening is done for actively traded stocks in the following countries: Sweden, Norway, Denmark, Iceland and Finland. Furthermore, it includes stocks in the Biotechnology & Pharmaceuticals as well as the Medical Equipment sub-sectors according to the Bloomberg Industry Classification System (BICS). The BICS classifies companies into different industries according to their general business activities, and their definition of Biotechnology and closely related industries aligns well with our idea of what the sample should consist of. The BICS is appropriate to use because it gives a good representation of the firms that we want to include in the study. There are many ways of defining Biotechnology and there is no one objective definition or criteria that may be used. However, the Bloomberg Industry Classification System does provide a good proxy for the companies that operate within the Biotechnology and closely related industries and will therefore be appropriate to use in this study.

The screening process resulted in 251 matches and after filtration and elimination of companies that lack enough data, the final number of companies in the sample is 36. It is quite common to end up with significantly fewer firms than the ones that are first selected. For example, in Allan

C Eberhart's (2004) study on the effect of R&D increases, the authors started with a sample size of 35404 firm-year observations and ended up with a final sample size of 8313 firm-year observations. The elimination in our study is done to help ensure that the conclusions about the effect of R&D expenditures will be more reliable as the data would be more complete with few missing variables and data points. More specifically, we exclude firms that didn't report R&D expenditures for a whole year during 2013 – 2022, which is the time period used for this study. We also exclude companies that did not exist throughout this whole time period. Furthermore, firms with no revenue were also excluded from the study because such firms will have very skewed values for R&D intensity and could thus skew the results of the study.

The sample is studied during the period of January 1st, 2013, until January 1st, 2022. This period should be long enough to provide reliable conclusions from the regressions, especially considering the large number of datapoints when using daily data. Daily data frequency will is therefor used for this study. Other studies have used high data frequency such as daily data which usually results in a more accurate analysis than data collected at less frequent intervals. For example, Hammoudeh and Alesia (2004) used daily data to study the relationships among the stock markets in the GCC and oil futures. Others have also used daily data to study financial markets; Bachemeier (2008) used daily data when studying the effect of oil price shocks on the U.S. stock market.

This also provides a larger number of observations which is beneficial given the relatively small number of firms to be studied. It should be noted that companies report their research and development expenditures once every quarter. The research and development expenditures are reported by the firms on the income statement in the quarterly and annual reports. This means that the expenditures will stay the same for every day during a given quarter i.e., we have the same value for R&D intensity for the whole quarter. Data on the volatility and the return are presented at a daily frequency.

Data about R&D intensity (R&D/Net sales ratio), stock total returns, and volatility is retrieved from the Bloomberg terminal, the Bloomberg spreadsheet builder is used for this purpose. Supplementary data about market capitalization, total assets, revenue and the Bloomberg estimates ratings is also collected using the Bloomberg spreadsheet builder. The R&D/Net sales ratio (firm R&D intensity) is given by Bloomberg, and it expresses the expenditures of R&D as a percentage of net sales. To measure the volatility (risk) of the stocks, Bloomberg's volatility 30-day measure is used. In this study we do not make a distinction between systematic and unsystematic risk as we are not using abnormal returns, instead we use the volatility measure to represent total risk. All data is collected in SEK currency using the options in the spreadsheet builder.

5.2. Variables and Descriptive statistics

We start our analysis by importing the raw data retrieved from Bloomberg spreadsheet builder into STATA. After that, some adjustments for the variables are made to make sure that they are standardized and ready to be used for the regression analysis. All variables are scaled properly and expressed in the same currency.

Table 1. Summary statistics for the variables used to examine the effect of R&D intensity on total stock returns.

VARIABLES	N	mean	sd	min	p50	max
Rating	84,319	2.580	1.764	0	3	5
volatility	84,319	0.444	0.324	0.0351	0.366	5.888
RD	84,319	0.426	2.235	0	0.0749	31.33
marketCap	84,319	8.143	2.456	2.594	8.077	14.71
totalAssets	84,319	7.202	2.152	2.035	6.949	12.50
revenue	83,334	5.434	2.257	-0.856	5.188	10.86
rated	84,319	0.733	0.443	0	1	1
return	84,319	0.00136	0.0346	-0.796	0	1.417

Table 1. above summarizes some statistical properties of the variables used in our analysis. The "Rating" variable is retrieved from Bloomberg and is the rating out of five according to

Bloomberg Estimates analysts. This variable is then used to construct the dummy variable "rated", where the dummy takes a value of zero when the firm is not rated by Bloomberg and the value of one when the firm is rated by Bloomberg, regardless of what rating is given. Moreover, we find that 26.72% of the observations have a value of zero which means that they do not have a Bloomberg rating (see Table 2).

Table 2. The frequency distribution of the dummy variable "rated".

rated	Freq (Percent)
0	22,533***
	(26.72)
1	61,786***
	(73.28)
Total	84319

The variable “return” is the total day to day return expressed in decimal form. It measures the total return between the prior day and the current day. The return measure is gross dividends. This will be a dependent variable used in the regression analysis. A graphical representation of the distribution of the daily returns is shown in Figure 3. below.

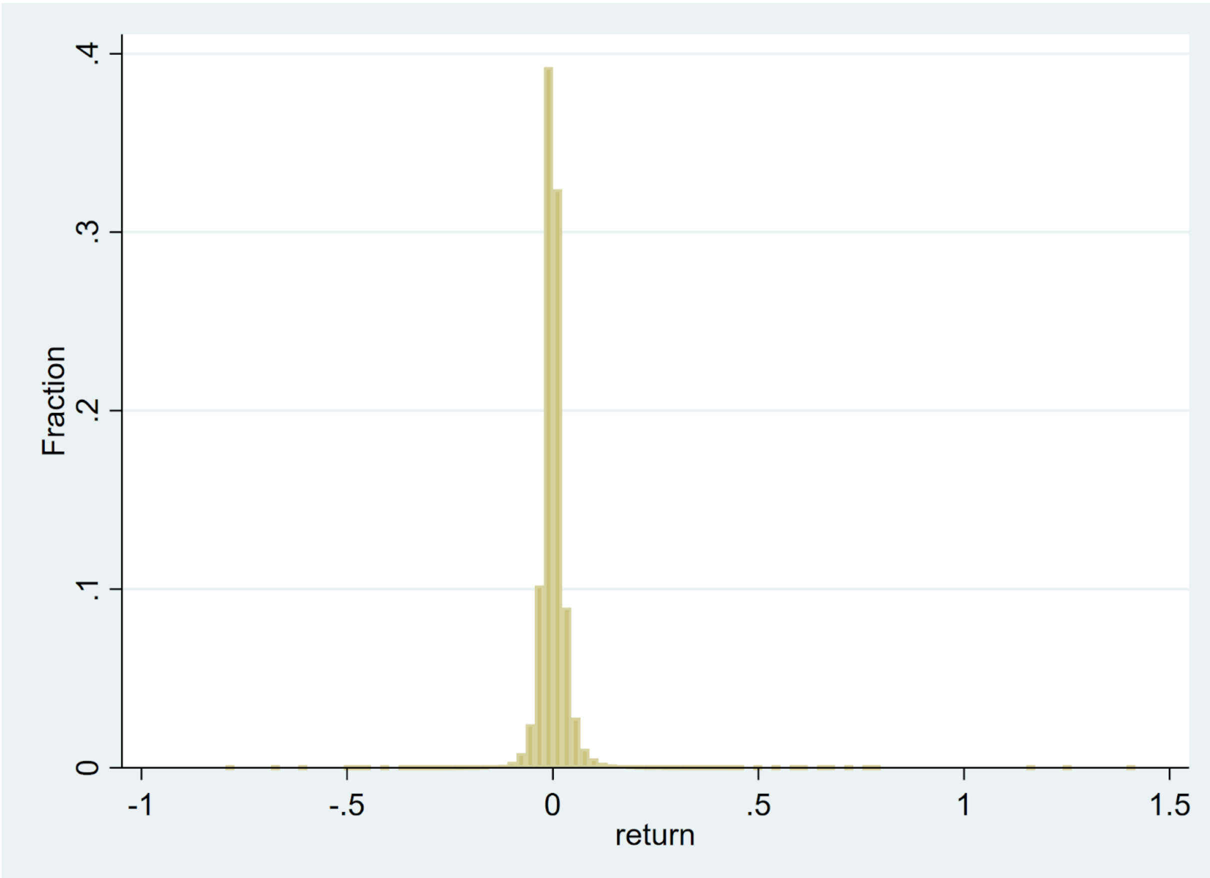


Figure 3. Distribution of the variable "return" which represents the total daily returns of the firms included in the sample.

To express R&D intensity we use the variable “RD" which, as previously mentioned, is the ratio of R&D expenditures over net sales. In Chan et al. (2001) and many other papers cited in the literature review, the same measurement for R&D expenditures is used - meaning that this falls in line with existing literature. The R&D expenditures and revenue are the values reported on the firm’s income statements and they are expressed in the currency SEK. This is the independent variable in the regression analysis. The measure is expressed in decimal format.

The variable "volatility" is the measure of risk of price movements of the stocks, it is used as a control variable. It is calculated from the standard deviation of day-to-day logarithmic historical price changes, and it is one of the control variables used in the regression. "volatility" equals the annualized SD of the relative price change for the closing prices of the 30 most recent trading days. Like the variables "return" and "RD", "volatility" is also expressed in decimal format and not in percentage format. The variables "marketCap" and "totalAssets" are also used as control variables in the regression. Values for the current market cap and total assets are retrieved using the Bloomberg spreadsheet builder and are expressed in SEK. The values for market capitalization are calculated as (Shares outstanding on day *i* * closing price on day *i*). The values for total assets are the values reported on the firms' balance sheets.
The log values of market capitalization and total assets are used to construct the variables "marketCap" and "totalAssets". The variables used in the regression are thus logged values.

Table 3. below illustrates a correlation matrix between the variables. It is shown that RD and volatility are positively correlated. This means that firms with a higher R&D intensity have more volatility in their stock price. We also see a positive correlation between return and volatility which is notable considering the previous findings of studies on the relationship between risk and return. For example, Shab Hundal (2019) found a strong and significant relationship between total risk and return.

Rating is negatively correlated with both return and volatility, implying that firms that have a Bloomberg rating also have lower returns and lower risk. This might be due to the fact that firms that have a rating are more stable and attract more institutional investors. As opposed to firms that do not have a rating which might be firms that are volatile and attract speculators.

Table 3. Correlation matrix for variables included in the regression analysis

	return	volatility	RD	marketCap	totalAssets	revenue	rated
return	1						
volatility	0.0364***	1					
RD	-0.00580	0.0821***	1				
marketCap	-0.00188	-0.420***	-0.0372***	1			
totalAssets	-0.0146***	-0.419***	-0.0749***	0.904***	1		
revenue	-0.0103**	-0.412***	-0.249***	0.851***	0.927***	1	
rated	-0.0101**	-0.272***	0.101***	0.666***	0.622***	0.506***	1
N	84319						

t statistics in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

5.3. Model specification

Some previous studies about R&D and their relation to company fundamentals have used cross-sectional data. Meaning that they analyze the data for each company at one fixed point in time. For example, Baruch Lev and Theodore Sougiannis ran cross-sectional regressions to study the the effects of R&D on returns Lev and Sougiannis (1999).

In this study panel data is used instead of cross-sectional data. This is because panel data can provide more accurate results since it offers more observations for each company. This is especially true in the case of this study considering the relatively few number of companies studied. By using panel data and daily values for the variables, a total number of 84,319 observations is reached for the 36 firms.

To examine the association between R&D intensity and the total return of stocks i.e., to see if firms with higher R&D intensity have higher returns, we run a panel-regression. The regression model is inspired by Fama and French's model where the return of a stock is dependent on a number of variables including a measure of risk. Fama and French use cross-sectional regressions where they have stock returns as the dependent variable and size, beta, leverage, and other variables as regressors Fama (1992). In this study, we have return as the dependent variable and R&D intensity as the independent variable. Multiple regressions are performed with a number of control variables.

The following regression models are used in the study:

(1) $return_t = \alpha + \beta_1 volatility_t + \beta_2 RD_t + \beta_3 marketCap_t + \epsilon$

Where:
return is the daily total return of the stock at time t. This return measure includes dividends. volatility is a measure of risk, and it is calculated from the standard deviation of day-to-day logarithmic historical price changes.
RD is the ratio of R&D expenditures/Net Sales. This is expressed in decimal format and is calculated as (R&D Expenditures/Revenue).
marketCap is the total market value of all of the company's outstanding shares at time t.

In the first model, we try to explain the total daily returns by three regressors. We include our variable of interest *RD* with two other control variables. Volatility is used to control for effects on the total returns arising from the stock being risky and thus investors demanding a higher premium for holding the stock.

marketCap is used to account for the effects of size, expressed by current market capitalization, on total returns.

(2) $return_t = \alpha + \beta_1 volatility_t + \beta_2 RD_t + \beta_3 marketCap_t + \beta_4 totalAssets_t + \epsilon$

Where:
totalAssets is the value of total assets as reported on the balance sheet expressed in SEK.

In the second model we include an additional control variable “totalAssets”. This is done in order to account for the potential relationship between a firms R&D intensity and total assets. In this model the effect of the two measures is separated and this could lead to better observing the true effect of R&D intensity.

(3) $return_t = \alpha + \beta_1 volatility_t + \beta_2 RD_t + \beta_3 marketCap_t + \beta_4 totalAssets_t + \beta_5 rated + \epsilon$

Where:
rated is a dummy taking a value of one when the stock has a Bloomberg rating.

The third model includes one additional variable to the second model. The dummy variable rated is included to examine the effect of a Bloomberg rating on the total daily returns. The variable is included to see if the effect of R&D intensity varies among firms who are rated by Bloomberg and those who are not.

The dependent variable is return which shows the total return of the stock gross dividends. The dividends are included in the return to measure both the capital gain and dividends from the stocks. If R&D intensity does lead to innovation and subsequently larger profits, it is more fitting to use the total returns instead of the capital gains i.e., price changes alone. This is done to capture the effect of R&D intensity on the total value for shareholders and not just the changes in stock price.

RD is the variable name for R&D intensity and a measure of R&D intensity is used instead of an absolute R&D expenditure value as the absolute value might differ widely depending on the size of the firm. Using a ratio makes it possible to compare how much the firm prioritizes spending on R&D in relation to its net sales. This is especially true since all firms operate in the

Biotechnology industry. It is less useful to compare the R&D intensity of firms in different industries, as there may exist large differences in R&D intensities between different firms as was argued by Nivoix and Ngunyen (2014).

A measure of market capitalization is included as a control variable to account for the size factor. It is clear from previous literature that the size of the firm i.e. the market cap plays a role in determining the returns of the firm's stock. The SMB factor in the Fama and French model (1993) represents the size factor. The value of the firm's total assets is also included in the analysis as a control variable. This control variable is included to account for the differences that might result from firms having larger assets. The dummy variable "rated" is added to the third regression to see if firms rated by Bloomberg have better total returns. It is reasonable to assume that the ratings will affect investor sentiment and expectations about the stocks and thus affect the prices and returns of stocks.

5.4. Fixed vs. random effects model: Hausman test

We use the Hausman test to choose whether a fixed effects or random effects regression model is more appropriate for our sample according to Greene (2008). The test is performed to see if we can reject the null hypothesis that a random effects model is superior. The alternative hypothesis in this case is that the fixed effects model is superior.

For model (1), the p-value was 0.0001 and thus the null hypothesis is rejected i.e., the fixed effects model is preferred and is used in the analysis. The test shows that the unique errors and the regressors are correlated which means using a random effects model is not appropriate.

For models (2) and (3) the-p value is zero and thus the null hypothesis is rejected, resulting in the fixed effects model being used for all three regression models.

6. Results

This section presents the results of the regressions performed to examine the effect of R&D intensity on the total stock returns for the sampled firms. Three fixed-effects panel regressions are run with the total daily return as the dependent variable.

From Table 4. below we can see that, when using model (1) which measures the effect of R&D intensity on total returns with volatility and marketCap being the only control variables, RD is not statistically significant at any level of significance when using a fixed effects model. This means that the null hypothesis that the effect of R&D intensity is different from zero cannot be rejected. It cannot be concluded from model (1) that a higher R&D intensity would lead to higher or lower total stock returns, or vice versa. In other words – that it has an effect at all. The results from this regression indicate that the level of R&D intensity does not have an explanatory power on stock returns when controlling only for the volatility and size effects.

The regressors “volatility” and “marketCap” in model (1) are statistically significant at the 1%level. Both regressors have positive coefficients with volatility having a larger coefficient thanmarketCap.
“volatility”, which measures total risk both systematic and unsystematic, is positively associated with total returns. This indicates that firms that are more volatile with higher price fluctuations, provide higher total returns. This is to be expected as volatility is an important factor affecting stock returns with higher volatility positively correlated with higher returns. Investors will require a higher risk premium to invest in stocks with high volatility. Sharpe (1964) showed that stocks with a lower and higher beta have lower and higher expected returns, respectively. Beta is a measure of systematic risk which is a component of the total risk measured by “volatility”. “marketCap” is also positively associated with total returns, indicating that firms with a higher market capitalization provide higher total returns.

When introducing one more control variable, “totalAssets”, in model (2), we see that the effect of RD in this model is statistically significant at the 5% level. The coefficient is negative, and this indicates a negative relationship between R&D intensity and total stock returns. However, the coefficient is very close to zero and relatively small compared to the coefficients of the other

regressors. This result deviates from studies showing that R&D intensity is positively associated with stock returns. On the other hand, the results align more with studies showing a weak or non-existent relationship between R&D and stock returns, Chan et al. (2001), Bloch (2003).
The regression results from the second model shows that, when controlling for the effect of total assets, the level of R&D intensity has explanatory power in explaining the daily total returns. The negative coefficient indicates that investors receive lower total returns from firms that have high R&D intensity. The regression provides evidence that allows us to reject the null hypothesis that there is no relationship between R&D intensity and total stock returns.

The dependent variable used in this regression is a measure of total returns and thus it includes capital gains and dividends. Therefore, lower total returns could be the result of either investors valuing R&D intensity negatively and this affecting the stock price (capital gain) negatively, or it could be the result of firms paying lower dividends to the investors. A negative total return could also be the result of the two effects combined: lower dividends and lower stock price.

According to the efficient market hypothesis developed by Fama (1970), the price of a stock should reflect all information. R&D intensity is public information and is readily available to investors, both net sales and R&D expenditures are presented on the income statement of the firms. Thus, the results of our regression align with the semi-strong form of the efficient market hypothesis given that part of the change in total daily return is due to changes in the stock price. Investors value R&D intensity negatively and expect firms with larger R&D intensity to have worse performance in the future. This could be due to their belief that the firms might not succeed in developing a profitable new drug or product.

The control variable for total assets is statistically significant at the 1% level. The variable has a negative coefficient indicating that total assets and daily total returns share a negative relationship.

Adding one additional control variable i.e., the dummy variable “rated” in model (3) does not change the results of the regression much compared to model (2). “RD” is still statistically significant at the 5% level with a slightly smaller coefficient. From this model we can again reject the null hypothesis that there is no relationship between R&D intensity and total stock returns. The dummy variable “rated” takes a value of one when the stock has a rating by Bloomberg and zero when it is not. The variable is statically significant at the 1% level. The coefficient is negative which means that having a Bloomberg rating negatively affects the total returns. This result seems counterintuitive as one would expect that stocks that are rated by Bloomberg analysts. However, there are potential explanations as to why having a rating is negatively associated with daily total returns. One possibility is that investors do not believe, or value ratings given by analysts. Investors may have feelings of distrust towards rating agencies, especially after the 2008 financial crisis. Perhaps the best explanation is that the ratings given by Bloomberg analysts are generally low. From Table 1. in the methodology and data section, it could be seen that the variable rating has a mean of 2.58 out of 5. This indicates that firms with a rating could have a low rating that negatively affects the sentiment of investors and thus the stock price, and subsequently the total daily returns.

The implications that can be drawn from this study are that R&D intensity has a negative effect on the total daily returns. This effect could be due to three reasons. Firstly, the negative effect on total returns could be the result of lower stock prices due to investors valuing R&D intensity negatively. Secondly, the effect could be a result of firms with high R&D intensity having lower revenue and thus have lower dividends to the investors. Lastly, the effect could be the result of a combination of investors negatively valuing R&D intensity and the negative effect on revenue and the subsequent effect dividends. Practically, this could mean that investors should avoid investing in firms with very high R&D intensities as these firms seem to have lower total returns. This is especially the case for investors with a short time horizon that value the daily returns highly. Furthermore, the results indicate that investments made into R&D do not lead to the benefit of the shareholders. Thus, corporate leaders need to be more deliberate when evaluating different investments in R&D if their goal is to increase shareholders returns.

Table 4. Regression results with total daily returns as the dependent variable

VARIABLES	Model (1): two controls variables	Model (2): three control variables	Model (3): three control variables
volatility	0.00461***	0.00436***	0.00439***
	(0.000440)	(0.000441)	(0.000441)
RD	-9.04e-05	-0.000151**	-0.000153**
	(7.03e-05)	(7.06e-05)	(7.07e-05)
marketCap	0.000903***	0.00228***	0.00240***
	(0.000162)	(0.000229)	(0.000233)
totalAssets		-0.00242***	-0.00239***
		(0.000285)	(0.000285)
rated			-0.00198***
			(0.000736)
Constant	-0.00801***	-0.00165	-0.00143
	(0.00134)	(0.00153)	(0.00154)
Observations	84,319	84,319	84,319
R-squared	0.002	0.003	0.003
Number of Company	36	36	36
Company FE	YES	YES	YES

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

6.1. Robustness testing

In this section, further regressions are run to test the validity of the results presented in the previous section. We start by examining the relationship between revenue and R&D intensity. The economic intuition tells us that revenue would affect the total stock returns. There are two mechanisms at play here. Firstly, the level of current revenue could be an indication of the level of future revenue of the firm. Investors use the current revenue to make their forecasts about future revenue and subsequently determine the estimated stock price today. This affects the capital gain portion of the total stock returns. Secondly, having lower revenue could mean that the firms pay lower dividends to their shareholders, and this affects the dividends portion of the total returns. Consequently, having lower revenue indicates that a firm will have lower total stock returns. If R&D intensity negatively affects total stock returns, then we expect to see a negative relationship between R&D intensity and revenue as well.

The dependent variable in the regression is "revenue" which represents the logged values of the revenue of each company. As shown in Table 5. R&D intensity is statistically significant at the 1% level in all three regressions. This could offer further insight into the mechanism in which R&D intensity affects the revenue of a company and the subsequent total return. This tells us that having a high R&D intensity is associated with lower revenue and lower total daily returns.

Furthermore, we create a dummy variable for R&D intensity "dummyRD" where the variable takes the value of 0 if the firm does not have R&D expenditures and thus has an R&D intensity of zero and the value of one when the company has R&D expenditures regardless of their magnitude in relation to sales. We use this dummy variable to test the effect on total daily returns by running a regression with volatility, marketCap, totalAssets and the dummy variable rated as control variables. From this regression we find that dummyRD is statistically significant at the 5% level and has a negative and very small coefficient compared to the coefficients of the other control variables. This means that firms who spend a portion of their revenue on R&D have a slightly lower total return than firms who do not engage in R&D activities at all.

Table 5. Regression results to examine the effect of R&D intensity on total daily returns

	(1)	(2)	(3)
VARIABLES	dependent var = revenue	dependent var = revenue	dependent var = revenue
volatility	-0.261***	-0.178***	-0.172***
	(0.00631)	(0.00510)	(0.00505)
RD	-0.118***	-0.0982***	-0.0988***
	(0.00103)	(0.000838)	(0.000829)
marketCap	0.520***	0.125***	0.149***
	(0.00231)	(0.00264)	(0.00267)
totalAssets		0.703***	0.709***
		(0.00333)	(0.00329)
rated			-0.373***
			(0.00846)
Constant	1.347***	-0.546***	-0.515***
	(0.0192)	(0.0179)	(0.0177)
Observations	83,334	83,334	83,334
R-squared	0.430	0.629	0.637
Number of Company	36	36	36
Company FE	Yes	Yes	Yes

Standard errors in parentheses

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

7. Discussion & Conclusion

In this paper, the impact of R&D investments on stock returns in the Nordic biotechnology industry has been examined. On a national level, R&D investments is often expressed in the form of R&D intensity which is a measurement that takes R&D expenditures divided by GDP. On a firm level, it is defined as R&D expenditures over net sales. The Biotechnology industry is fast growing and one of the most R&D intensive. It is very broad and encompasses many areas such as technology for agriculture, food, and medicine, for example. The last one, medicine, is the reason why Biotechnology and Pharmaceuticals industries often collaborate – causing them to be analyzed together in many instances. The Nordic countries are often mentioned in the context of Biotechnology and innovation and as shown by the Bloomberg Innovation Index of 2021, Sweden, Denmark, and Finland are highly innovative. These things combined makes it interesting to investigate whether market investors value R&D expenditure in this industry and region, and this would be reflected in stock prices and the subsequent total returns.

As for the results, we find evidence that R&D intensity has a significant but marginal effect on the daily total stock returns for the firms studied. The nature of this effect is unexpected as it is shown from the empirical analysis that R&D intensity has a negative effect on the total stock returns. It is found that R&D intensity also has a very small but significant negative impact on the revenue of the firms. Furthermore, it is found that firms who engage in R&D activities i.e., firms with a positive R&D intensity have lower stock returns than firms who do not engage in R&D activities. It should be noted however that the effect of R&D intensity on stock total returns, although negative and significant, is very small. The results of this study are partially consistent with previous literature showing no direct relationship between R&D intensity and stock returns. For example, Chan et al. (2001) and Bloch (2003) fail to show a direct link between R&D and stock returns.

A potential reason for the negative coefficient may be that the sample consists of a lot of profit firms which, as shown in Franzen and Radhakrishnan (2009), has a negative relationship between R&D intensity and stock returns. Moreover, the time period chosen might seem sufficiently long at first, but it could be argued that it is not long enough to study the true effect of R&D. This might be especially the case when studying Biotechnology & Pharmaceutical firms considering the long time it takes for a new drug to be developed, approved, and sold in the markets. A different result from the one reached in this study could therefore be possible if a longer time period had been used to analyze the effects of R&D. A longer time period could provide enough time for R&D investments to be materialized into profitable products. Also, the sample size in this study is not very large and it might be hard to draw clear conclusions about R&D and stock returns based on a relatively small sample size. Although small, the sample size is representative of firms active in Biotechnology and closely related industries in the Nordic countries. To increase the sample size, future research may look to expand the geographical scope and study the impact of R&D for firms in western Europe.

Daily total stock returns has been used in this study. It is worth noting that daily returns could be affected by several factors that do not relate to the fundamentals of the firms. Daily returns are partially affected by market sentiment and liquidity factors that do not relate to the investments in R&D by the firm. Using quarterly or yearly returns could perhaps be a more appropriate approach to estimate the true effects of R&D intensity.

This study adds further empirical evidence to the relationship between R&D activities and stock returns in the Nordic countries. It demonstrates that the relationship between R&D and total stock returns is significant but marginal. The results provide evidence that investors give negative value to R&D investment made by firms in the Nordic Biotechnology sector.

This could be due to the fact that investors believe that many investments made by firms to develop new products will fail to be successful and will not lead to future gains for the firm – or will take a very long time to materialize.

More research is needed to provide further evidence for the nature and magnitude of the relationship between R&D and stock returns. Future studies should investigate these effects and include a larger sample size and/or a longer time period. Additionally, future studies should examine the relationship of the increases and decreases of R&D expenditures on stock returns. Another area for future research would be to estimate the long-term effect of R&D on stock returns. Moreover, additional research could be done to complement that of Jiang, Kose and Larsen (2020) to further learn about the relationship between R&D and the volatility of stock prices.

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