ERASMUS UNIVERSITY ROTTERDAM
Erasmus School of Economics

Bachelor thesis Economics and Business Economics

Impact of the Global Financial Crisis on the relationship between R&D investment and market value: a study of European listed companies

Name student: Teodora Đokić
Student ID number: 577448td

Supervisor: dr. Ruben de Bliek
Second assessor: dr. Haikun Zhu

Date final version: August 11, 2023

Abstract

This thesis studies the effect of R&D investment of private sector European companies on their market value, and how this effect changed due to the Global Financial Crises (GFC) of 2007-2008. I performed a regression analysis using the entity fixed effects model on a sample of 218 European companies over the period of 2003-2013 and found a significant positive relationship between R&D investment and market value. However, the findings also showed that this relationship was negatively affected by the GFC, as the relationship between R&D investment and market value became negative during and after the GFC. These results suggest that R&D investment generally has benefits for the firm and is recognized by investors. However, it is procyclical in nature and its riskiness is likely to be of great concern for the investors during economic downturns.

Table of Contents

1. Introduction

Continuous development of new technological advancements has proven to be essential for innovation and economic well-being. Because of this, over the past few decades economists have given a great deal of attention to research and development (R&D) investments by the private sector, or in other words investment in the improvement and development of products and services. With global markets becoming more and more competitive, managers' decisions regarding R&D investment can have a great influence on the future growth, viability, and competitiveness of a company (James & McGuire, 2016). On a greater scale, the importance of collective decision-making by managers on R&D investment goes beyond the private benefit of shareholders, it also shapes future innovation and economic development.

The effect of R&D investment on the market value of a firm is found to be positive by most economic researchers (Bae & Kim, 2003; Johnson & Pazderka, 1993; Lome et al., 2016). This is intuitive, as R&D investment in a successful project is likely to create a competitive advantage for the company. In turn, this should be reflected in the market value of that company and recognized by financial markets. In economic research, market value is often used as an indicator of the firm's expected economic returns from investing in R&D (Bosworth & Rogers, 2001). However, the relationship between R&D investment and the market value might not be as straightforward and robust as one might think. Although R&D expenditure is documented in the firm's financial statements, this does not provide any information on its quality or success (Edmans, 2011). Moreover, R&D projects are commonly associated with high uncertainty, which often results in a lack of trust in the benefits of R&D investments (Chan et al., 2001; Vo & Le, 2017; Xu & Sim, 2018). During difficult economic times, this lack of trust is likely to be amplified, which in turn reduces the R&D activity of the private sector. Consequently, economic downturns are likely to challenge the relationship between R&D investment and market value.

I intend to study the relationship between R&D investments and market value, and what happens to this relationship when the economy is not doing well. I will be empirically testing the evidence on the effect of R&D investment on the market value of EU companies, and how this effect changed as a consequence of the Global Financial Crisis (GFC) of 2007-2008.

I chose to study R&D investment during the period of GFC not only because of the immense impact it left on the global economy but also because of the difference between the theoretical predictions and the actual outcome. The theory of creative destruction by Joseph A. Schumpeter, one of the most renowned theories of innovation, suggests that during a recession, resources will be allocated towards new entrants and projects that will replace existing ones, which will drive innovation in the economy (Schumpeter, 1942). In other words, R&D investment should be countercyclical: increase during economic downturns and decrease during economic upturns. However, this is not what we saw in practice with the GFC. Roper and Turner (2020) find that innovation and R&D investment of UK firms were much lower during the GFC (2008-2010) than before (2006-2008) and that only larger firms managed to fully recover in the years following the crisis. It is noteworthy to mention that most of the research in the field of R&D investment and market value has been done on US and UK firms. This leaves a gap in our knowledge about R&D investments among European firms. According to Hall and Oriani (2006), the business environment of the EU differs from that in the US and the UK by having (1) different legal regimes and ownership structures among publicly listed firms, (2) a lower presence of professional investors and somewhat looser discipline exerted by stock markets. Due to these differences, extrapolating results from US and UK data might be misleading for managers of EU companies. Therefore, with my thesis, I hope to provide new insight into how R&D investment affects the market value of firms in Europe, and how was this relationship challenged by the GFC. Following this, my research question is: "How did the Global Financial Crisis affect the relationship between R&D investment and the market value of a firm?"

To study this relationship, I will take a sample of publicly listed EU firms for the period of 2003-2013. Although the UK had been a part of the EU during the time frame I am looking at, I will not be including it in my research due to the fact that its stock market exhibits different behavior than the ones of other EU countries, as discussed above. The panel data was obtained from Refinitiv Eikon. I will be using the entity fixed effects model, where the variable of interest will be R&D investment, measured with the R&D/Sales ratio to allow for a better interpretation of results. For the dependent variable, I will use a market-based performance measure price-to-sales (P/S) ratio, which is calculated by taking the company's market capitalization (share price multiplied by number of shares outstanding) and divided by total sales. The reason for using this measure as a dependent variable is that the market price is a good reflection of the public's opinion on the company's investment decisions (Ehie &

Olibe, 2010). The regression model will also include controls for the size and leverage of companies within the sample. To assess the potential impact of the GFC on the relationship between R&D investment and market value, I will introduce an interaction effect of R&D investment and the period during and after the GFC took place (2008-2013), by creating a dummy variable which will take the value 1 during the stated period and 0 otherwise.

In the literature studying the connection between R&D investment and a firm's market value, there seems to be a general agreement that the relationship is a positive one. However, difficult economic times are likely to challenge this relationship. Schumpeter's theory of creative destruction, along with many modern researchers, argues that innovation should increase during these times and be more valued in the market. However, there is evidence that suggests that financial constraints that took place during the GFC are likely to reverse this positive relationship. With my thesis, I hope to add to the existing literature by analyzing how the R&D investment of EU companies changed in response to the GFC, and to what extent did that impact their market value. Considering that most of the economic and financial literature found a positive relationship between R&D investment and market value (as a general trend, independent of the period of economic crises), I expect to obtain the same results. Furthermore, considering the specificity of the GFC and the fact that its main consequence was even tighter financial constraints, I expect to find a negative relationship between R&D investment and the market value during and after the GFC in Europe.

My thesis will be divided into six chapters, where Chapter 2 will be dedicated to a literature review on the topics relating to R&D investment, market value, and the GFC, and setting up my research expectation in the form of two hypotheses. In Chapters 3 and 4, I will be describing the data collection process, the methodology used for my analysis, and ultimately the results which will test the two hypotheses independently. A robustness analysis will be included in Chapter 4. Furthermore, Chapter 5 will be dedicated to the discussion of the results and how my findings relate to the previous literature. Lastly, Chapter 6 will provide concluding remarks and potential limitations of my research.

2. Theoretical Framework

2.1 R&D Investment

R&D investment is the investment undertaken by a private or public sector entity aimed at creating or increasing its intangible capital (Griliches, 1981). In the private sector sphere, this intangible capital could manifest itself in the form of knowledge that is unique to the firm and is therefore a source of competitive advantage, which competitors could benefit from through imitation (James & McGuire, 2016). According to Xu and Sim (2018), this is particularly important in a modern-day dynamic business environment characterized by fast-changing consumer preferences, technology, and competition, because having a competitive advantage is essential for a firm's viability in the market. Thus, firms spend large amounts of money on R&D to find its source and in turn improve their performance. Furthermore, Ehie and Olibe (2010) find that nowadays firms derive more value from their intangible assets, such as product branding and services, rather than their physical architecture, and that successful R&D investment helps firms differentiate themselves from their competition. On top of that, Hitt et al. (2001) argue that intangible assets are likely to result in a long-lasting competitive advantage and thus a better positioning of a firm in the market. R&D is also likely to improve a firm's absorptive capacity, the ability to recognize the value of new outside knowledge, which should consequently boost its performance and create valuable commercial opportunities (Cohen & Levinthal, 1990).

Over the past few decades, R&D investment has caught the attention of countless economic researchers and has been considered a source of private benefits for the firm, by means of long-term growth opportunities and technological advancements, but also a constituent of economic growth (Alam et al., 2020). Technological advancements and knowledge creation that come from R&D investment lead to the introduction of new products, services, and ways of doing business, which creates innovation in the economy (Roper & Turner, 2020). Cardoso and Teixeira (2009) argue that because modern-day society is primarily knowledge-based, innovation is becoming vital for economic growth, and with innovation and technology being synergetic, technological advancement becomes a driving force of economic growth. They also emphasize that R&D investment has been positively associated with economic growth, hence why economists are giving a great deal of attention to assessing the performance of R&D investments on both micro (firm and industry) and macro (regions and country) levels.

The connection between the micro and macro levels, according to Stam and Wennberg (2009), comes from the fact that firms imitate each other's innovative strategies, and by doing so collectively contribute to society's knowledge about productive possibilities. Even if an individual firm does not manage to reap the benefits of its investment, this knowledge will spill over and benefit society. The first academic to study innovation as a driver of economic growth was the Austrian economist Joseph A. Schumpeter. After the Second World War, the global economy posed a need for new solutions to help rebuild the global economy. During this time, Schumpeter (1942) argued that economic development can only be sustained through "creative destruction", where old products, technologies, and ways of doing business shall be replaced by new innovations and technological advancements, making them more productive and efficient. Introducing novel products, technologies, and ways of doing business challenges the existing market dynamic and puts pressure on incumbent firms to stay competitive. However, if they fail to do so, they will be forced out of the market and resources will be reallocated towards new, innovative projects. This links back to my previous discussion from the more modern literature on competitive advantage and its significance in the market, which shows that Schumpeter's ideas on innovation remain relevant in the discussion on R&D investment almost a century later. Furthermore, another well-renowned study that acknowledges the impact of technological advancement on economic growth is the Solow growth model, by considering technological progress as an exogenous driver of economic growth. Solow (1956) defines technological progress as developments in knowledge, innovation, and advancements in technology that lead to a higher level of efficiency and productivity in the production process, and are crucial for long-term, sustained economic growth.

Studies on R&D investment began around the 1980s, when economists started looking into the private benefits that firms could get by investing in R&D. At the time, one of the most renowned researchers in the field was Zvi Griliches, who studied how the level of R&D expenditure connects to productivity and market value of a firm. In two of his seminal studies on R&D, he found that R&D had a significant and positive effect on the productivity growth of a firm and contributed positively to its market value (Griliches, 1981, 1985).

Although R&D investment has been proven to bring private benefits to firms and public (social) benefits to the overall economy through innovation, it comes with a significant level of risk and uncertainty. As Hay and Morris (1979) suggested, R&D investment can be

considered a high-risk-high-reward strategy. This implies that it can bring all the benefits discussed earlier if the investment project succeeds, but also great losses if the investment project fails. This is usually because projects that aim to create intangible assets tend to be difficult to evaluate and require a long-term commitment, which creates uncertainty around the investment required for them (Xu & Sim, 2018). The further in the future potential returns are, the higher the uncertainty. Because of all uncertainties surrounding R&D investments, projects could be passed on even though they had the potential to create great private benefits and positive spillover effects.

2.2 Private Sector R&D Investment in Europe

R&D investment is a well-researched topic among US and UK companies, whereas that is not the case for European companies. According to Hall and Oriani (2006), making conclusions on European companies based on data from the US and the UK would not lead to valid conclusions, as European countries have (1) different legal regimes and ownership structures among publicly listed firms, which are particularly important for the market valuation of R&D investments and can favor firm's insiders; and (2) a lower presence of professional investors and somewhat looser discipline exerted by stock markets, which reduces the pressure imposed by financial markets and thus increases the propensity for long-term investments. Black and Fraser (2000) researched short-termism in the UK stock market, and they found that a Continental European country such as Germany will be less inclined to evaluate projects on a short-term horizon. A country's attitude towards financial returns is one of the factors impacting the level of its private sector R&D investment, as it has been shown that profits and cash flow decisions have a higher and more significant effect on investment decisions in the US and the UK than in Continental European countries such as Germany, Belgium and France (Bond et al., 2003; Mulkay et al., 2001). Altogether, the propensity for long-term investments and lower pressures on financial performance on the stock market allows for more tolerance towards lengthy R&D investment projects in Continental Europe, which could potentially be of great innovative value but could also allow for provenly unsuccessful projects to continue for too long.

Because of the significance of European countries in the global economy and their innovative potential, it is important for policymakers and managers to have a clear picture of what impact their R&D-related decisions will have. As pointed out by Stam and Wennberg (2009),

getting Europe on a high-growth path by increasing R&D investment is crucial for increasing the number of new market entries and competition.

2.3 Relationship between R&D investment and the market value of a firm

The relationship between R&D investment and the firm's market value has been thoroughly studied in economics and finance literature. The market value of a firm represents a firm's value as perceived by the stock market, in the case of publicly listed companies. The reason why market value is often studied as the outcome of R&D investment, according to Ehie and Olibe (2010), is that the fact that it is a good representation of how the public perceives a firm's value, and with that how it perceives the firm's level of R&D activity. Moreover, market value is a forward-looking performance measure, meaning that it incorporates the public's valuation of the expected future stream of profits, which stems from the firm's tangible and intangible assets (Bosworth & Rogers, 2001).

Anagnostopoulou (2008) reviewed the literature available on R&D expenditure and its benefits, one of many being the performance in the stock market, for which the article finds that there is a persistent positive relationship that proved to be robust in research done across the US and the UK. My own literature review yielded similar findings, that the majority of economic literature agrees on a positive relationship between R&D investment and the market value of a firm (Bae & Kim, 2003; Johnson & Pazderka, 1993). A positive relationship between R&D investment and the market value of a firm is one that has been predicted by economic theory. According to the theory of efficient markets, investors should be able to recognize the firm's value beyond what is stated in its books, and therefore make a good estimate of a firm's intangible assets (Chan et al., 2001). Therefore, considering that investment in R&D creates intangible assets for the firm, the market should incorporate the level of R&D investment in its valuation of the firm even if the payoff is not immediate, because the present value of expected returns from R&D projects should be reflected in the valuation (Griliches, 1981).

However, the market does not always see only the positives about R&D investment. Because of the vast amount of uncertainty surrounding R&D projects, firms that invest a large amount of funds into R&D are considered risky. Chan et al. (2001) found that a high level of R&D investment only leads to a marginally higher stock return because investors associate high R&D with highly volatile returns, and that firms with high R&D investment had comparable

stock returns to those with no R&D investment. They argue that the two reasons behind this outcome could be (1) the lack of accounting information regarding intangible assets, and (2) the fact that most valuation models are based on estimates of future earnings, which could be misleading due to the accounting practice of including R&D expenditure into operating expenses. Some researchers even found a negative relationship between R&D investment and market value. Erickson and Jacobson (1992) found that the stock market reacts adversely to R&D investment, the reason being that the market only rewards activities that generate current period operating income, while R&D activities are perceived as purely profit-reducing.

To put the discussion in the context of European countries, we should think about how European investors react to the potential benefits and uncertainties of R&D investment. Returning to my discussion in Section 2.2, we know that the financial markets of EU countries (other than the UK) exert on average less pressure than those of the US and UK where most of the research has been done, and also have more tolerance towards long-term investment projects. Although very few studies have been done on R&D investment and its subsequent effect on the market value of a firm, Hall and Oriani (2006) performed a comprehensive study on European companies and found a positive relationship. For these reasons, I expect that European financial markets will put more value on R&D investment. Therefore, my first hypothesis is:

H1: R&D investment has a positive and significant effect on the market value of a firm.

2.3.1 Relationship during the Global Financial Crisis (GFC)

There is a lot of debate in the literature on how the relationship between R&D investment and the market value of the firm shall be impacted by an economic crisis. The debate has been ongoing for almost as long as innovation has been studied, since Schumpeter (1934) discussed innovation during turbulent economic times in his works. He argued that the outcome of an economic crisis would be one where there are plenty of idle resources and lower factor prices, which shall create opportunities for new projects and with that innovation. Moreover, his theory of creative destruction states that at the end of the 'destruction' period of the cycle, which can be interpreted as the period of a crisis, resources

shall be reallocated towards projects that bring innovation and boost economic development. By this reasoning, R&D investment should go against the business cycle.

Yet, there still seems to be a lack of literature providing appropriate guidance to managers of firms on how they should go about R&D during turbulent economic times (Lilien & Srinivasan, 2010). The existing literature seems to be divided into those who (1) like Schumpeter, believe that R&D is especially significant during times of crises because it helps the firms be more resilient to economic turbulences and aids economic development, and (2) those who believe that increased risk-awareness and financial constraints present during economic crises will decrease the willingness and ability of firms to invest in R&D. In the former case, the literature argues that R&D improves the firm's adaptive, absorptive and dynamic capabilities, which (1) increase its ability to react to external turbulence, (2) make it better equipped to exploit new opportunities that arise during the financial crisis and (3) overall better suited to handle a financial crisis (Cohen & Levinthal, 1990; Freel, 2000; Griffith et al., 2004; Lome et al., 2016). According to the theory of efficient markets, investors should recognize this value during turbulent economic times, and thus attach a higher value to firms possessing these abilities, making the market value of these firms higher. Furthermore, Xu and Sim (2018) argue that investment in R&D leads to products that are not easily substituted by cheaper alternatives, especially bringing value during an economic crisis. Stocks of firms producing this type of product are considered "defensive stocks" by investors and tend to be the most valued during economic downturns. On the other hand, in the letter case, the opinion of researchers is based on the fact that R&D is associated with great uncertainty, which is likely to be amplified during times of crises because financial capital is limited. Building upon previous discussions about R&D uncertainty and investor's preference for short-term profits, it is likely that the additional factors present during the financial crisis such as lack of financials means, will result in less value being attached to firms that invest in somewhat risky R&D projects. Paunov (2012) that due to financial constraints that occurred during the GFC in Latin America, around 25% of the firms invested less in innovation.

Hodson and Quaglia (2009) summarized the impact of the GFC on European countries and highlighted the severe economic slowdown and a cutback in funds that took place during the crisis. It is therefore obvious that Europe was not spared by the catastrophic consequences that the GFC brought. However, research done on R&D investments and the stock market

performance of companies during this period leads to inconclusive results. Schmitz (2014) performed a study on German firms and their response to the recession, and found that firm size played the most significant role in determining relative R&D intensity, where small firms reduced their spending on R&D significantly more than large firms. This could be attributed to the fact that smaller firms find it more difficult to source funding than large firms, and thus financial tightening is likely to affect smaller firms more than large firms. López-García et al. (2013) found similar results in their research on Spanish firms, where they concluded financial constraints are likely to reverse R&D investments' usual trend, which is countercyclical, and therefore cause a reduction in R&D spending during a financial crisis such as the GFC. On the other hand, a polarizing conclusion was reached by Lome et al. (2016), who found that among Norwegian companies R&D investments proved to be a significant determinant of success during the GFC. The results showed that fraction of companies that managed to maintain their positive financial performance during the crisis, R&D intensity was much higher than among the rest of the companies that experienced a decline in their performance. This suggests that the companies that were highly R&D intensive before the crisis managed to maintain their financial health during the crisis.

Considering that most of the literature found that a significant fraction of European companies suffered during the GFC and that tighter financial constraints were in place, I expect to find that the GFC negatively impacted the relationship between R&D investment and the market value of a firm. Thus, my second hypothesis is:

H2: The GFC had a negative impact on the relationship between R&D investment and the market value of a firm.

3. Data and methodology

3.1 Data

To test the two hypotheses mentioned in Theoretical Framework, and ultimately answer the research question "How did the Global Financial Crisis affect the relationship between R&D investment and market value?", I will be using panel data on active publicly listed European companies for the period 2003-2013. The data was obtained through Refinitiv Eikon, an open-technology solution that collects financial data from companies worldwide. The companies were selected based on their status (active and publicly listed), the country where the headquarters are located, and their market capitalization. Considering the outcome variable is the market value of a firm, I have only selected publicly listed companies that were active throughout the period. Companies were selected from countries that were EU members throughout the period, as this allows for consistency and controls for the potential effect of external economic factors. I have excluded the UK, because the literature review indicated that R&D investment has been thoroughly studied among UK companies, often jointly with the US companies, and the UK stock market differs significantly compared to those of other EU countries, as noted by Hall and Oriani (2006). Therefore, the final sample consists of companies from Belgium, Germany, France, Italy, Luxemburg, Netherlands, Austria, Sweden, Finland, Spain, Portugal, Greece, Denmark, and Ireland. Lastly, I only considered companies that had a market capitalization of at least 250 million euros, which is a threshold for the company's stock to be considered "small cap". Therefore, the sample includes "small cap" and "big cap" companies and thus allows for consideration of different stock behaviors. From this selection, the initial sample contained 1875 companies. This sample was further cleaned, and the companies that did not have data on R&D expenses were excluded as they could not be used for my research. It is noteworthy to mention that only a fraction of companies selected in the sample had data on their R&D expenditure. One plausible explanation for this could be the fact that these expenses are recorded under operating expenses in the Income Statement, which potentially makes them difficult to extract from Financial Reports. Finally, I also made sure that all the companies in the sample had data available on the price-to-sales ratio, as this will be my measure of market value. After removing all the missing values, I reached the final sample of 218 companies, with historical data on all variables for the period 2003-2013. In total, this leaves 2,398 complete

observations (complete data present for each variable). The number of companies per country and per industry can be found in Appendix A.

To measure the effect that R&D investment has on the market value of a firm, I will look at the *R&D/Sales ratio*, which will be my main variable of interest and the predictor in the relationship. It is calculated by dividing the company's R&D expenditure for the financial year by its total sales for the same year, which allows for an easier interpretation of results and accounts for differences in sales amounts across companies. The *R&D/Sales ratio* is likely to differ across industries, as innovation-dependent and highly competitive industries, usually high-tech industries, are likely to spend more money on R&D than monopolistic industries such as the raw materials (Vo & Le, 2017). To measure the outcome, I will use the *price-to-sales (P/S) ratio*. The *P/S ratio* is a proxy for the market value of a firm, and it reflects the value that investors place on each euro of a company's total sales. Therefore, a high value would indicate that investors would pay a lot of money for a euro of the company's sales. It is calculated by dividing the company's share price (market value per share) by the amount of its total sales per share, and it often is measured on an annual basis as it uses the total annual sales of the company. It is therefore a market-based performance measure that provides a good reflection of the market's valuation of a company's assets and expectations on its future performance (Ehie & Olibe, 2010). The *P/S ratio* as a measure of market value could be a potential solution regarding the bias on R&D investment valuation because it does not take into account the earnings of a company (current or projected) which are used in most of the traditional valuation models and are likely to downplay the potential benefits of R&D as pointed out by Chan et al. (2001). With both variables being deflated by total sales and measured as a ratio, the interpretation of the results will be more straightforward.

To control for potential omitted variable bias, I will be incorporating *Size* and *Leverage* variables as controls. Larger firms are more likely to be efficient and enjoy economies of scale when it comes to R&D investment, which is why larger firms tend to invest more in R&D than smaller firms. According to Chiang and Mensah (2004), the larger the firm the more value it manages to create through R&D investment. Therefore, when discussing the market valuation of R&D investment, it is crucial to consider the impact that the company's size can have on its engagement in R&D. To account for this, I will be using the variable *Size*, which will be approximated by net sales of a company. Considering that I am looking at

the financial items of a company, using sales as the measure of size was the most appropriate practice. The net sales amount is measured in euros, but to allow for a more straightforward interpretation of results I performed a logarithmic transformation on the variable. Furthermore, *Leverage* accounts for differences in capital structure between different companies in the sample. To approximate the effect of leverage, I will use the companies' debt-to-asset ratio. The ratio is calculated by dividing the company's total debt by its total assets. Is often the case that highly leveraged companies (with a high debt-to-asset ratio) face greater financial constraints and high default risk, which is likely to impact the funds available for investing in the R&D (Xu & Sim, 2018). Although it is intuitive to think that there is a negative effect of leverage on the R&D investment, as found by Filatotchev and Piesse (2009), Bond et al. (2005) found that financial constraints arising from debt financing have no consequence on long-term investments such as R&D.

The summary of descriptive statistics can be found in Table 3.1. It is interesting to note that the company with the highest value for *R&D/Sales ratio* within the sample is Genmab, Danish scientific research (more specifically biotechnology) company. Another interesting insight is that the company that had the highest valuation, as measured by the *P/S ratio*, is the Dutch pharmaceutical company Pharming Group NV. The same company also had one of the highest R&D/Sales ratios in the sample. Scientific research-based industries, such as biotechnology and pharmaceuticals, are characterized by high involvement in R&D, which explains the high value of the *R&D/Sales ratio* (Perlitz et al., 1999). However, neither of the companies was among the largest in the sample by net sales.

Table 3.1
Descriptive statistics

	Mean	Std.Dev.	min	max
P/S ratio	3.52	54.69	0.02	2456.45
R&D/ Sales ratio	0.20	2.40	0.00	79.33
Net Sales	15,388,366.21	32,042,518.75	147.00	310,367,000.00
Leverage ratio	0.21	0.14	0.00	0.82
Observations	2398			

Note. The table shows the summary statistics of the four variables used. P/S Ratio, R&D/Sales Ratio, and Leverage Ratio are expressed as ratios, where the mean value of 0.20 for the R&D/Sales Ratio tells us that the company's R&D expenditure makes up 20% of its total sales, while for the Leverage Ratio the mean value of 0.22 tells us that the company's debt amount is comparable to 22% of its asset amount. Size is measured in euros.

3.2 Methodology

To analyze my data and obtain statistical inferences needed to answer my research question and make my conclusion, I will be using the entity fixed effects model. The entity fixed effects model is a panel data model that controls for omitted variables that differ across individuals but are constant over time. There are likely certain characteristics of a company, such as business practices, company culture, or long-term goals of the company, that could be correlated with the company's level of R&D activity. These characteristics are not likely to change over time, as they are a part of the company's business practice. However, these characteristics are likely to differ between the companies and could potentially lead to biased results on how R&D investment affects the market value of a firm, which is why we need the entity fixed effects model to account for these differences. To confirm that the entity fixed effects model is indeed a better fit, I performed the Hausman test to check whether these individual characteristics are indeed correlated with the variables in the model. The coefficient was significant at a 5% significance level, therefore we can reject the null hypothesis of no correlation. This confirms that the fixed effects model is a better fit. Lastly, robust standard errors will be used to account for potential heteroskedasticity in data.

To test my first hypothesis stating that R&D investment has a positive and significant effect on the market value of a firm, I will be taking the data for the entire sampled period (2003-2013) and applying the following formula:

$$P/S\ Ratio_{it} = \alpha_i + \beta_1 R\&D/Sales\ Ratio_{it} + \beta_2 Size_{it} + \beta_3 Leverage\ Ratio_{it} + u_i + e_{it}$$

where α_i is the intercept, $\beta_{1,2,3}$ are coefficients, u_i is the within-entity error term (or within estimator) and e_{it} is the overall error term. i is the company indicator and takes values from 1 to 218, while t is the time indicator and takes values from 1 to 11 (1 being the year 2003).

To test the second hypothesis on whether the GFC negatively affected the relationship between R&D investment and the market value, I will be extending the formula used to test the first hypothesis, and I will be looking at an interaction effect of a dummy *Crisis* and the predictor variable *R&D/Sales Ratio. Crisis* dummy takes the value 1 for the period including the aftermath of the crisis (2008-2013) and 0 otherwise. This leaves the following formula:

$$P/S\ Ratio_{it} = \alpha_i + \beta_1 R\&D/Sales\ Ratio_{it} + \beta_2 Size_{it} + \beta_3 Leverage\ Ratio_{it} + \beta_5 Crisis \text{ x } R\&D/Sales\ Ratio_{\text{it}} + u_i + e_{it}$$

4. Results

The following results were obtained through the entity fixed effects model by analyzing a set of panel data on 218 European companies for the period 2003-2013. The model aims to estimate the effect of the *R&D/Sales ratio* on the *P/S ratio* for all companies within the sample. As both variables are expressed as ratios, if the *R&D/Sales ratio* of a given company changes by 0.01, its *P/S ratio* will change by β_1 times 0.01. In other words, keeping the total sales constant and increasing the R&D expenditure by 1 percentage point will lead to β_1 percentage point increase in *P/S ratio*. β_1 represents a common effect across all companies, controlling for individual heterogeneity.

Section 4.1 of this chapter will be dedicated to giving a formal answer to the first hypothesis, which stated that R&D investment has a positive and significant effect on the market value of a firm, while Section 4.2 will be dedicated to testing the second hypothesis stating that the GFC weakened the relationship between R&D investment and the market value of a firm. Finally, section 4.3 will be dedicated to the robustness analysis where a broader sample was considered, and a slightly different way of measuring R&D investment was utilized.

4.1 Hypothesis 1: R&D investment has a positive and significant effect on the market value of a firm

To test the first hypothesis, three models were estimated: (1) the baseline model including only *R&D/Sales ratio* and *P/S ratio*, (2) the baseline model extended by controlling for *Size*, and (3) the model fully extended by including both controls, *Size* and *Leverage ratio*. The regression results are summarized in Table 4.1.

Considering we are looking at the entity fixed effects model, the important measure for goodness of fit is the within R^2, which in this case is approximately 0.39 for all three models. This implies that all three models, regardless of adding control variables, explain around 39% of the variance in the *P/S ratio* across companies. Moreover, the fact that the goodness of fit does not change between models indicates that controlling for the size and leverage of a company does not add any explanatory power.

Table 4.1
Regression results for H1

	(1) P/S ratio	(2) P/S ratio	(3) P/S ratio
R&D/Sales ratio	16.23**	16.16**	16.19**
	(7.53)	(7.52)	(7.57)
Size (in euros)		-1.14	-1.51
		(1.07)	(1.40)
Leverage ratio			-41.62
			(40.75)
Constant	0.23	17.07	31.41
	(1.52)	(15.52)	(27.80)
Observations	2398	2398	2398
Within R^2	0.39	0.39	0.39
Between R^2	0.96	0.95	0.89
Overall R^2	0.51	0.50	0.49

Note. Robust standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In Model 1, the coefficient of the *R&D/Sales ratio* is positive and statistically significant at a 5% significance level, and the magnitude of the coefficient is 16.23. This implies that a 0.01 increase in the *R&D/Sales ratio* of a company results in a 0.1623 increase in a *P/S ratio*. In other words, a company increasing its R&D expenditure by 1 percentage point is expected to result in a 16.23 percentage points increase in its stock price in the same year, and ultimately its market value (assuming that the amount of its outstanding shares and total sales remains unchanged). Therefore, my first hypothesis that R&D investment has a significant and positive effect on the market value of a firm holds.

The control variable *Size* exhibited a negative coefficient, meaning that a company that has relatively high net sales is associated with a lower market valuation in Models 2 and 3. On the other hand, when it comes to the leverage ratio of a company, the literature had mixed views. In Model 3, we find a negative coefficient of the *Leverage ratio* combined with a high magnitude, implying that a high amount of debt is associated with a relatively lower market valuation. However, neither of the controls were statistically significant therefore I can only comment on the association of each with the market value, but not draw any statistical inferences.

4.2 Hypothesis 2: The GFC had a negative impact on the relationship between R&D investment and the market value of a firm

To test the second hypothesis, I used the same three models as in Section 4.1, however with the added moderation effect of the GFC. The models will be numbered 4-6 for distinction purposes, where Model 4 is the baseline model without controls for size and leverage. The moderation effect was accounted for by including the interaction effect of the *R&D/Sales ratio* and the *Crisis* dummy, which can tell us how the GFC affected the relationship between R&D investment and the market value of a firm. The coefficient of the interaction effect can be interpreted as the difference in the effect of a change in the *R&D/Sales ratio* for R&D investments made during the period of 2008-2013 compared to the period of 2003-2007, or in other words during the aftermath of the GFC compared to the preceding period. Results are summarized in Table 4.2.

The $Within\ R^2$ of all three models is 0.54, indicating that all models performed slightly better when the interaction effect was included. This means that the three models with the added interaction effect explain on average around 54% of the variation of the *P/S ratio* across all companies and that splitting the period in consideration to 'before' and 'after' the GFC gives us a more accurate prediction of the *P/S ratio* than looking at the period as one, which was done for the first hypothesis.

The coefficient of the *R&D/Sales ratio* in the baseline model (Model 4) is positive and statistically significant at a 10% significance level, with a magnitude of 18.11. Similar to the results of the first hypothesis, we see that R&D investment does have a significant effect on the market value, however at a lower significance level and with a higher magnitude. This means that if the *R&D/Sales ratio* increases by 0.01, the *P/S ratio* should increase by 0.1811. However, considering that I included the interaction effect, this interpretation holds for the period before the GFC (2003-2007), when the *Crisis* dummy takes a value of 0. In other words, keeping total sales and shares outstanding constant, the baseline model can be interpreted as follows: during the period before the GFC (2003-2007), an increase in R&D expenditure by 1 percentage point would lead to an increase of 18.11 percentage points in the market value of a firm. However, during the aftermath period of the GFC (2008-2013), we

see a reversal in this relationship. The interaction effect represents a difference between the two periods, before and after the GFC. The coefficient of the interaction effect is negative and statistically significant at a 1% significance level, with a magnitude of 21.37 in the baseline model. What this tells us is that increasing the *R&D/Sales ratio* by 0.01, during the period of 2008-2013, would result in a *P/S ratio* that is lower by 0.2137 compared to what it would be if the ratio had increased by the same amount during the period of 2003-2007. Following the same logic as for the period preceding the GFC, we can deduce that an increase in the R&D expenditure by 1 percentage point during this period would in fact decrease the market value of a firm by 3.26 percentage points. Overall, I can conclude that the GFC had in fact strengthened the relationship between R&D investment and market value and transformed it into a negative one. With this evidence, I can state that my second hypothesis holds in my research.

Table 4.2
Regression results for H2

	(4) P/S Ratio	(5) P/S Ratio	(6) P/S Ratio
R&D/Sales ratio	18.11*	18.23*	18.23*
	(9.84)	(9.97)	(9.98)
Crisis x R&D/Sales ratio	-21.37***	-21.39***	-21.26***
	(4.25)	(4.26)	(4.18)
Size (euros)		2.15	1.78
		(2.38)	(2.04)
Leverage ratio			-26.62
			(25.62)
Constant	0.91	-30.44	-19.34
	(2.04)	(36.51)	(26.51)
Observations	2398	2398	2398
Within R^2	0.54	0.54	0.54
Between R^2	0.79	0.70	0.71
Overall R^2	0.58	0.56	0.57

Note. Robust standard errors in parentheses: * *p < 0.10,* ** *p < 0.05,* *** *p < 0.01*

When adding controls in Models 5 and 6, we see that the control for size has a positive effect on the *P/S ratio*, which is different compared to the analysis done for the first hypothesis. This suggests that larger companies can be associated with a higher market valuation. Meanwhile, the control for leverage remains negative with a high magnitude, which would imply that companies with a high debt-to-asset ratio are associated with a much lower market valuation. However, as in the analysis for H1, both controls are not statistically significant, therefore we cannot draw any conclusions on their effect on the market valuation. Moreover, the fact that the model's goodness of fit does not improve with adding controls suggests that they do not add any explanatory power to the market valuation of the companies within the sample.

4.3 Robustness analysis

In this section I will perform a robustness analysis as in Sections 4.1 and 4.2 with the same methodology, however with a slightly different sample and measurement of R&D investment. The purpose of this addition is to check for the robustness of the results found in the previous sections of this chapter, namely confirming whether my two hypotheses hold when the analysis is performed on a different sample and using a different R&D-related ratio.

The sample selection for this analysis was performed similarly to the previous one, the only difference being that the restriction on the firm's market capitalization has been removed. By including the companies with a lower market capitalization, I obtained a larger sample which initially included 4985 companies. Furthermore, R&D investment will be measured by the *R&D/Net Sales ratio*, where the R&D expenditure will be divided by net sales instead of total sales. Ehie and Olibe (2010) suggest that using the *R&D/Net Sales ratio* provides a better adjustment to a firm's size than using the absolute measure of R&D. I calculated this ratio myself by dividing the company's R&D expenditure by its net sales for the same year. Both variables used to calculate the ratio were obtained through Refinitiv Eikon as the rest of the data. I decided to use the *R&D/Net Sales ratio* for the robustness analysis only, and not the primary analysis, because it does not allow for a straightforward interpretation as the *R&D/(Total) Sales ratio* does. The *R&D/(Total) Sales ratio* also accounts for the size of the company through total sales and allows for a direct interpretation of what will happen to the market value of a company when it increases its R&D expenditure because total sales are also used to calculate the *P/S ratio*.

Due to the limited availability of data on R&D expenditures and P/S ratios of companies, the sample has not been directly expanded, but rather a different sample was reached after removing missing values. Descriptive statistics of this sample can be found in Appendix B.

In Table 4.3 we can see the results for H1. The coefficient is positive and statistically significant at a 1% significance level. Comparing this result to the primary analysis, we see that the coefficient has a smaller magnitude but is more statistically significant. Overall, this suggests that the first hypothesis holds in the robustness analysis. On the other hand, the coefficient of the interaction effect of the *Crisis* dummy and R&D investment remains negative, as found in the primary analysis, but is no longer statistically significant and exhibits a much lower magnitude (Table 4.4). Therefore, there is not enough evidence to support the second hypothesis in the robustness analysis.

It is also interesting to point out that the goodness of fit of all the models in the new sample is better than in the primary analysis. On average, all models explain around 80% of the variation in the P/S ratio across all companies in the sample.

Another interesting insight is that when removing the minimum requirement for the market capitalization of a company from the sample, the control for size becomes statistically significant at 10% for the first three models (when the effect of the GFC is not being taken into consideration).

Table 4.3
Regression results for H1

	(1) P/S ratio	(2) P/S ratio	(3) P/S ratio
R&D/Net Sales Ratio	5.86***	5.75***	5.74***
	(0.19)	(0.16)	(0.16)
Size (in euros)		-15.89*	-16.87*
		(9.38)	(10.12)
Leverage Ratio			-9.79
			(8.57)
Constant	2.77***	224.16*	239.86*
	(0.10)	(130.65)	(142.65)
Observations	3234	3234	3234
Within R^2	0.79	0.80	0.80
Between R^2	0.93	0.45	0.42
Overall R^2	0.81	0.69	0.67

*Note. Robust standard errors in parentheses: * p < 0.10, ** p < 0.05, *** p < 0.01*

Table 4.4
Regression results for H2

	(4) P/S Ratio	(5) P/S Ratio	(6) P/S Ratio
R&D/Net Sales Ratio	5.87***	5.73***	5.71***
	(0.22)	(0.19)	(0.18)
Crisis x R&D/Net Sales Ratio	-4.19	-4.97	-4.99
	(5.54)	(5.61)	(5.60)
Size (in euros)		-19.54	-20.98
		(11.91)	(12.91)
Leverage Ratio			-11.42
			(9.08)
Constant	4.23***	273.42*	295.61
	(0.98)	(164.80)	(180.47)
Observations	3234	3234	3234
Within R^2	0.80	0.80	0.81
Between R^2	0.89	0.34	0.31
Within R^2	0.80	0.64	0.62

*Note. Robust standard errors in parentheses: * p < 0.10, ** p < 0.05, *** p < 0.01*

5. Discussion of results

Results presented in Chapter 4 were mostly in line with what the literature review in Chapter 2 predicted, namely that (1) there is a strong positive relationship between R&D investment and the market value of a firm, and (2) the GFC had a negative impact on this relationship.

As for the first point, the majority of academic research found similar results and concluded that investing in R&D generally leads to better performance on the stock market and a higher market value (Anagnostopoulou, 2008; Bae & Kim, 2003; Bosworth & Rogers, 2001; Hall & Oriani, 2006; Johnson & Pazderka, 1993). As Chan et al. (2001) argued, assuming that the theory of efficient markets holds, investors recognize that R&D investment leads to the creation of intangible assets that improve a company's operating performance and market position, which thus place a higher value on their stocks. On the other hand, my results conflict with the findings of Erickson and Jacobson (1992), who argued that the stock market only values investments that bring immediate payoffs and should therefore place a lower valuation on companies who invest intensively in R&D. As Griliches (1981) mentioned in his nominal study on R&D investment, the market values R&D beyond the timing of its payoffs. My findings on the relationship between R&D investment and market value also proved to be robust to a different analysis (using a different sample and a different way of measuring R&D investment).

As for the second point, my findings show that the relationship between R&D investment and market value had become negative during and after the period of the GFC. This result is similar to the one of López-García et al. (2013), who found that the generally positive relationship between R&D investment and market value is likely to be reversed during financial crises due to tighter financial constraints. As Hodson and Quaglia (2009) stressed, the EU faced significant cutbacks and financial constraints during the GFC. The combination of economic shocks that were present during the GFC and the tendency of financial markets to prioritize short-term returns during the period of financial crises seem to explain the harsh reversal in the relationship between R&D investment and market value. The opposing opinion was proposed by Schumpeter (1942), who introduced the theory of creative destruction and argued that companies that innovate are likely to be more resistant to financial constraints brought by economic crises. This view was also supported by a significant number of modern economics literature, with the main argument being that

companies that invest in R&D have better capabilities needed to survive a crisis (Cohen & Levinthal, 1990; Freel, 2000; Griffith et al., 2004; Lome et al., 2016). Overall, my findings favor the view that R&D investment is procyclical, and not favored by financial markets during the period of crisis. However, it is important to note that the findings did not show to be fully robust, as the robustness analysis exhibited a negative, but not statistically significant effect of the GFC on the relationship.

Controlling for the size and leverage of a company proved to be statistically insignificant in all six models I estimated. The control variable *Size* exhibited a negative coefficient in the regression performed to test H1, which was not expected considering that most of the literature finds that larger companies have more funds to invest in R&D, and in turn tend to have a higher market value (Chiang & Mensah, 2004; Xu & Sim, 2018). Moreover, Schmitz (2014) found that size was one of the most important determinants of R&D intensity in a company and that a financial crisis had a significantly larger impact on the R&D intensity of smaller than larger firms. On the other hand, the coefficient for *Size* was positive in the regression that tested H2, which leads me to inconclusive results about the direction of the effect of firms' size. Nevertheless, one thing that is certain is that my results do not show a significant impact of the control for firms' size and are therefore not in line with what the literature predicted. On the other hand, the literature had mixed views when it comes to the leverage level of a company. Because of the negative coefficient of *Leverage* combined with a high magnitude, my results favor the view that a high amount of debt not only puts companies in an unfavorable position to invest in R&D but also negatively affects their market value (Filatotchev & Piesse, 2009; Xu & Sim, 2018).

Overall, the literature had a clear standing that the relationship between R&D investment and the market value of a firm is a positive one, which my research also showed. However, there was no prevalent opinion in the literature on how this relationship would be affected by the financial crisis, and my findings favor the less optimistic (procyclical) view. When it comes to control variables, it was surprising that size had no significant impact on the market value, as the literature almost unanimously agrees that the company's size is one of the most important determinants of R&D intensity and market value.

6. Conclusion

In this thesis, I have looked at the effect that the R&D investment of private-sector European companies has on their market value, and how this effect changed as a response to the Global Financial Crises (GFC) of 2007-2008. R&D investment is considered a main driver of innovation in the private sector sphere, which in turn also drives innovation and economic development of countries and regions. Moreover, R&D investment brings private benefits to companies engaging in it, in the form of improved performance and better market positioning. However, R&D projects are characterized by long-term commitment of large funds and usually do not bring immediate payoffs, which makes them a risky investment that might not be attractive to investors. Because of this, companies might be reluctant to invest in innovative projects. Previous research has found that investing in R&D mostly has a positive effect on a company's market value and performance in financial markets in good economic times. However, the question is whether this relationship holds during times of economic crises. Perhaps the best example of such times was the GFC, which shook the global economy and imposed some of the tightest financial constraints seen in recent history. To determine how the relationship between R&D investment and the market value of firms responded to the GFC, I proposed a research question: "How did the Global Financial Crisis affect the relationship between R&D investment and the market value of a firm?".

To answer my research question, I collected a sample of 218 private sector companies with headquarters in countries of the European Union and analyzed their financial data over an 11-year period (2003-2013). The financial data included price-to-sales ratios (as a measure of market value), R&D/Sales ratios that measured the R&D intensity of companies, net sales as a measure of size, and debt-to-asset ratios as a measure of leverage. I performed a regression analysis using an entity fixed effects model and found that there is a significant positive relationship between R&D investment and market value during good economic times, however during the GFC this relationship had reversed as investing in R&D in the years following 2008 resulted in declines in the market value of a firm.

The study therefore concludes that European companies are generally likely to benefit from investing in R&D. This provides strong evidence not only of the benefits of R&D investments but also an insight into the preferences of investors in the European stock markets. The evidence suggests that European investors recognize the value of the creation of

intangible assets and innovation, and are not purely interested in short-term profits. However, my study also raises caution about investing in R&D during unstable economic periods, as the risks of committing to long-term projects are likely to become more concerning when funding options are limited. Although my study is focused specifically on the GFC, the consequences that ensued as a result of this particular crisis are not far different from those of other economic crises we experienced. In recent years, Europe saw economic downturns during the Covid-19 pandemic and the Russian-Ukrainian War, to which my findings could be applicable. Investing in R&D during times of crisis does not seem to benefit the companies undertaking them, however they might be crucial for the post-crisis recovery. Therefore, my suggestion for future studies is whether the public benefits of innovation outweigh the costs of private sector firms responsible for undertaking innovative projects.

The main limitation of my research is the lack of data available on the R&D expenditures of companies. R&D expenditures are treated as an operating expense and companies are not required to report them separately, which is the reason why only 218 out of 1875 companies from my initial sample had complete data available on their R&D expenditure during the time frame considered. Perhaps a more effective method, such as a survey to managers, or a more resourceful database could have resulted in a larger sample. However, as a student I had no access to such options. The second limitation of this research could be that it does not control for the industry concentration. The literature has suggested that more competitive industries encourage more innovation, as companies try to stay competitive. Unfortunately, I could not find a reliable way to control for it. Calculating the Herfindahl index myself has been considered as an option, however due to my relatively small sample, and the fact that many large European companies are still privately held, there was no reliable way for me to control for the industry concentration without causing bias in my research.

References

Alam, A., Uddin, M., Yazdifar, H., Shafique, S., & Lartey, T. (2020). R&D investment, firm performance and moderating role of system and safeguard: Evidence from emerging markets. *Journal of Business Research*, *106*, 94–105. https://doi.org/10.1016/j.jbusres.2019.09.018

Anagnostopoulou, S. C. (2008). R&D expenses and firm valuation: A literature review. *International Journal of Accounting & Information Management*, *16*(1).

Bae, S. C., & Kim, D. (2003). The Effect of R&D Investments on Market Value of Firms: Evidence from the U.S., Germany, and Japan. *Multinational Business Review*, *11*(3), 51–76. https://doi.org/10.1108/1525383X200300016

Black, A. J., & Fraser, P. (2000). International Comparisons on Stock Market Short-termism: How Different is the UK Experience? *The Manchester School*, *68*(s1), 38–50. https://doi.org/10.1111/1467-9957.68.s1.3

Bond, Harhoff, & Van Reenen. (2005). Investment, R&D and Financial Constraints in Britain and Germany. *Annales d'Économie et de Statistique*, *79/80*, 433. https://doi.org/10.2307/20777584

Bond, S., Elston, J. A., Mairesse, J., & Mulkay, B. (2003). Financial Factors and Investment in Belgium, France, Germany, and the United Kingdom: A Comparison Using Company Panel Data. *Review of Economics and Statistics*, *85*(1), 153–165. https://doi.org/10.1162/003465303762687776

Bosworth, D., & Rogers, M. (2001). Market Value, R&D and Intellectual Property: An Empirical Analysis of Large Australian Firms. *Economic Record*, *77*(239), 323–337. https://doi.org/10.1111/1475-4932.t01-1-00026

Cardoso, A., & Teixeira, A. A. (2009). Returns on R&D investment: A comprehensive survey on the magnitude and evaluation methodologies. *Institute for Systems and*

Computer Engineering of Porto, Innovation and Technology Transfer Unit, Working Paper.

Chan, L. K. C., Lakonishok, J., & Sougiannis, T. (2001). The Stock Market Valuation of Research and Development Expenditures. *The Journal of Finance*, *56*(6), 2431–2456. https://doi.org/10.1111/0022-1082.00411

Chiang, C. C., & Mensah, Y. M. (2004). The Determinants of Investor Valuation of R&D Expenditure in the Software Industry. *Review of Quantitative Finance and Accounting*, *22*(4), 293–313. https://doi.org/10.1023/B:REQU.0000032600.07130.fc

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. *Administrative Science Quarterly*, *35*(1), 128. https://doi.org/10.2307/2393553

Edmans, A. (2011). Does the stock market fully value intangibles? Employee satisfaction and equity prices. *Journal of Financial Economics*, *101*(3), 621–640. https://doi.org/10.1016/j.jfineco.2011.03.021

Ehie, I. C., & Olibe, K. (2010). The effect of R&D investment on firm value: An examination of US manufacturing and service industries. *International Journal of Production Economics*, *128*(1), 127–135. https://doi.org/10.1016/j.ijpe.2010.06.005

Erickson, G., & Jacobson, R. (1992). Gaining Comparative Advantage Through Discretionary Expenditures: The Returns to R&D and Advertising. *Management Science*, *38*(9), 1264–1279. https://doi.org/10.1287/mnsc.38.9.1264

Filatotchev, I., & Piesse, J. (2009). R&D, internationalization and growth of newly listed firms: European evidence. *Journal of International Business Studies*, *40*(8), 1260–1276. https://doi.org/10.1057/jibs.2009.18

Freel, M. S. (2000). Strategy and Structure in Innovative Manufacturing SMEs: The Case of an English Region. *Small Business Economics*, *15*(1), 27–45.

Griffith, R., Redding, S., & Reenen, J. V. (2004). Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries. *Review of Economics and Statistics*, *86*(4), 883–895. https://doi.org/10.1162/0034653043125194

Griliches, Z. (1981). Market value, R&D, and patents. *Economics Letters*, *7*(2), 183–187. https://doi.org/10.1016/0165-1765(87)90114-5

Griliches, Z. (1985). *Productivity, R&D, and Basic Research at the Firm Level in the 1970s*. w1547. https://doi.org/10.3386/w1547

Hall, B. H., & Oriani, R. (2006). Does the market value R&D investment by European firms? Evidence from a panel of manufacturing firms in France, Germany, and Italy. *International Journal of Industrial Organization*, *24*(5), 971–993. https://doi.org/10.1016/j.ijindorg.2005.12.001

Hay, D. A., & Morris, D. (1979). *Industrial economics: Theory and evidence*. Oxford University Press.

Hitt, M. A., Biermant, L., Shimizu, K., & Kochhar, R. (2001). Direct and moderating effects of human capital on strategy and performance in professional service firms: A resource-based perspective. *Academy of Management Journal*, *44*(1), 13–28. https://doi.org/10.2307/3069334

Hodson, D., & Quaglia, L. (2009). European Perspectives on the Global Financial Crisis: Introduction. *JCMS: Journal of Common Market Studies*, *47*(5), 939–953. https://doi.org/10.1111/j.1468-5965.2009.02029.x

James, B. E., & McGuire, J. B. (2016). Transactional-institutional fit: Corporate governance of R&D investment in different institutional contexts. *Journal of Business Research*, *69*(9), 3478–3486. https://doi.org/10.1016/j.jbusres.2016.01.038

Johnson, L. D., & Pazderka, B. (1993). Firm value and investment in R&D. *Managerial and Decision Economics*, *14*(1), 15–24. https://doi.org/10.1002/mde.4090140103

Lilien, G. L., & Srinivasan, R. (2010). Marketing Spending Strategy in Recessions. *Australasian Marketing Journal*, *18*(3), 181–182. https://doi.org/10.1016/j.ausmj.2010.06.002

Lome, O., Heggeseth, A. G., & Moen, Ø. (2016). The effect of R&D on performance: Do R&D-intensive firms handle a financial crisis better? *The Journal of High Technology Management Research*, *27*(1), 65–77. https://doi.org/10.1016/j.hitech.2016.04.006

López-García, P., Montero, J. M., & Moral-Benito, E. (2013). Business Cycles and Investment in Productivity-Enhancing Activities: Evidence from Spanish Firms. *Industry & Innovation*, *20*(7), 611–636. https://doi.org/10.1080/13662716.2013.849456

Mulkay, B., Hall, B. H., & Mairesse, J. (2001). Firm Level Investment and R&D in France and the United States: A Comparison. In D. Bundesbank (Ed.), *Investing Today for the World of Tomorrow* (pp. 229–273). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-56601-1_19

Paunov, C. (2012). The global crisis and firms' investments in innovation. *Research Policy*, *41*(1), 24–35. https://doi.org/10.1016/j.respol.2011.07.007

Perlitz, M., Peske, T., & Schrank, R. (1999). Real options valuation: The new frontier in R&D project evaluation? *R&D Management*, *29*(3), 255–270. https://doi.org/10.1111/1467-9310.00135

Roper, S., & Turner, J. (2020). R&D and innovation after COVID-19: What can we expect? A review of prior research and data trends after the great financial crisis. *International Small Business Journal: Researching Entrepreneurship*, *38*(6), 504–514. https://doi.org/10.1177/0266242620947946

Schmitz, T. (2014). Fluctuations in R&D investment and long-run growth: The role of the size distribution of innovating firms. *Manuscript, Bocconi University.* http://www-v202.rz.uni-mannheim.de/material/JMP_Tom_Schmitz_2_12_2014(1).pdf

Schumpeter, J. A. (1934). *The Theory of Economic Development*. Harvard Economics Studies.

Schumpeter, J. A. (1942). *Capitalism, socialism, and democracy* (1st ed.). Harper & Brothers Publishers.

Solow, R. M. (1956). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, *70*(1), 65. https://doi.org/10.2307/1884513

Stam, E., & Wennberg, K. (2009). The roles of R&D in new firm growth. *Small Business Economics*, *33*(1), 77–89. https://doi.org/10.1007/s11187-009-9183-9

Vo, L. V., & Le, H. T. T. (2017). Strategic growth option, uncertainty, and R&D investment. *International Review of Financial Analysis*, *51*, 16–24. https://doi.org/10.1016/j.irfa.2017.03.002

Xu, J., & Sim, J.-W. (2018). Characteristics of Corporate R&D Investment in Emerging Markets: Evidence from Manufacturing Industry in China and South Korea. *Sustainability*, *10*(9), 3002. https://doi.org/10.3390/su10093002

Appendix A: Data

Table A1
Number of companies per country in the sample

Country	Number of companies
Austria	8
Belgium	11
Netherlands	14
Germany	68
Spain	3
France	31
Ireland; Republic of	15
Denmark	16
Italy	11
Sweden	23
Finland	15
Luxemburg	2
Portugal	0
Greece	1
Total	218

Appendix B: Data for robustness analysis

Table B1

Summary statistics

	Mean	Std.Dev.	Min	Max
PS Ratio	5.84	98.37	0.02	4747.02
R&D/Net Sales Ratio	0.52	14.32	0.00	802.16
Net Sales (in euros)	11,528,333.09	28,359,433.97	147.00	310,367,000.00
Leverage Ratio	0.21	0.22	0.00	9.28
Observations	3234			

Note. The table shows the summary statistics of the four variables used. P/S Ratio, R&D/Net Sales Ratio, and Leverage Ratio are expressed as ratios, where the mean value of 0.52 for the R&D/Net Sales Ratio tells us that the company's R&D expenditure makes up 52% of its net sales, while for the Leverage Ratio the mean value of 0.21 tells us that the company's debt amount is comparable to 21% of its asset amount. Size is measured in euros.

Table B2

Number of companies per country in the sample

Country	Number of companies
Austria	10
Belgium	12
Netherlands	14
Germany	91
Spain	3
France	42
Ireland; Republic of	16
Denmark	18
Italy	12
Sweden	39
Finland	26
Luxemburg	2
Portugal	0
Greece	9
Total	294