The Effects of R&D Investments on Financial Performance: A comparison between high-tech and non-high-tech companies

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ABSTRACT,
This study investigates the effect research and development investments have on companies their financial performances. Financial performance is measured with three metrics: Return on Assets, Return on Equity and Profit Margin. The dataset is retrieved from G8 countries. Special attention is paid to high-tech and non-high-tech companies. In total 4512 companies are researched of which 892 are high-tech and 3620 are non-high-tech. An inverted U-shape relationship is tested in this study. Therefore, a squared function of the independent variable: research and development intensity is added. A regression is performed over a period of four years from 2014 until 2017. An inverted U-shape relationship is confirmed in the full sample as well as the split samples. The Return on Assets and Profit Margin show similar optimal percentage and curves, the Return on Equity does not. In the split samples Return on Equity and Profit Margin is larger in the high-tech sample than in the non-high-tech sample, but no statistical difference was found. A robustness check was performed with a 2-year lag that further confirms that findings in this study.

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Keywords
Research & Development, Financial Performance, Investments, High-tech versus non-high-tech, G8 countries.

1. INTRODUCTION

Research and development refers to activities companies undertake in the pursuit of producing new products and services. These new products and services in turn influence the financial performance of a firm. That can be both negative and positive. Research and development expenditure as compared to the gross domestic product of all the G8 countries is an important metric in this study. 'The total R&D expenditure is comprised of all expenditure done by all resident companies, research institutes, university and government laboratories, etc.(OECD, 2019)'. In this research the data from 2014 until 2017 is analyzed. These numbers are denominated to US dollars, because that's what the OECD and Orbis prefer in their statements.

This study is based on the world's leading industrialized countries. The G8, which is made up of Canada, The United States of America, The United Kingdom, Italy, France, Germany, The Russian Federation and Japan. G8 or group eight, was active from 1997 until 2014 when the Russian Federation was disinvited in that year. However, for the context of this study the G8 in itself is not important but the countries that make up this group are. All of these countries are highly industrialized countries with big financial markets. It is therefore interesting to see whether these industrial powerhouses perform research and development and to what extent. Together these eight countries are in the top 11 highest gross domestic product. (The United Stats of America nr1, Japan nr3, Germany nr4, The United Kingdom nr6, France nr7, Italy nr9, Canada nr10, and The Russian Federation nr11)(Worldmeter, 2019).

Research and development is a well-researched topic in the existing literature. However, most studies focus solely on The United States of America (Vo (2017) & Yu (2018) & Louis (2001)). Other studies have focused on OECD countries (Falk (2007)) and Europe (Coad (2019) & Hall (2006)). As of the moment of writing this thesis I am not aware of any studies performed on a G8 level.

The research question asked therefore is: 'To what extent do R&D investments contribute to a firm's performance?' When interpreting the results of this research question a distinction will be made between G8 high-tech companies and non-high-tech companies. The distinction is made because high-tech companies tend to have much more investments into R&D than non-high-tech companies (Eberhart et al 2014). For that reason, it is interesting to research whether R&D investments make a difference in R&D intensive industries and lower R&D intensity industries on a firm's financial performance.

Research and development expenditures vary among industries. This research does not only try to provide insight into what difference research and development intensity levels make on a firm's financial performance and then to generalize the results across the whole G8 market, but also to differentiate between two industries (high-tech and non-high-tech) so that the insight is more precise in what industry of the G8 market R&D investments have the most impact

2. THEORETICAL BACKGROUND

The impact from research and development on a firm's financial performance is well researched. In this section prior research will be reviewed and from these papers, three hypotheses will be made for this research. Research and development investments hold risks, therefore the return on investment of these investments are uncertain. Every investment into research and development forms a risk of capital for the firm. SME's tend to outsource its research and development department for various reasons, e.g. not having capable enough staff to set up a department or not having enough capital to spend on it. There are several theories that adhere to research and development. Three of which will be covered and that are familiar within the industry are: the knowledge-based view, the resource-based view and the organizational learning theory. They are shortly explained in the same order. The knowledge-based view (Grant, 1996) takes a firm into consideration and deems the 'knowledge' within a firm as most the important factor for research and development for the firm. Also noting that knowledge is difficult to recreate and if a firm has it, it can lead to a competitive advantage, an example of an industry that might use this method is the pharmaceutical industry. The knowledge-based view is seen as an extension of the resource-based view. Resource-based view (Barney, 1991) is the predecessor of the knowledge-based view. The resource-based view as the name suggests looks at the resources a firm has. The resources can be unique, like patents or new products that can give the firm a competitive advantage. As well as all assets and information and the firm's processes etcetera can potentially form into a competitive advantage. For R&D, the resources can also be that the firm has a lot of liquidity and is able to perform longer and better quality research and consequently develop a new product or service that will later develop into a competitive advantage, an example of an industry that can use this theory is the fossil fuel industry, usually they have a lot of liquidity and are able to sustain R&D departments. The core difference between the knowledge-based view and the resource-based view is that the first is about value creation and the latter about value extraction (Sullivan, 2000). Lastly there is the organizational learning theory (Argyria & Schon, 1978). This theory introduces the idea of the process of learning in a firm. Organizational learning comes from the interaction between a firm and an individual. Companies get better at R&D when they practice it more often, it becomes more efficient if a firm is able to shift the knowledge throughout the firm and thereby maintaining all of its competencies. An example of an industry that keeps on learning and putting a lot of effort into R&D would be the aerospace industry.

2.1 The impact of R&D on firms financial performance

'R&D intensity is positively associated with return volatility'(Louis et al, 2001). Their research is based on American companies by looking at the research and development intensity of companies, then comparing that to their stock return volatility. Further stating 'Companies with high R&D to equity market value earn large excess returns.' That means that high-tech companies have generally speaking have more 'large excess returns' than non-high-tech companies, simply because the former has a higher R&D to equity value than the latter.

Anagnostopoulou et al (2008), researched the persistence of R&D and its consequential firms' performance. They used a big data set for the United Kingdom from 1990 until 2003. They confirm that there is a positive relationship between R&D intensity and consistent growth in revenue, but only for companies that need to perform research and development because of the field that they are in. Their research concluded that R&D intensity improves the persistence in excess stock return. On average the companies that are the most R&D intense earned more than an average return persistently. The companies that are R&D intense are found to be more persistent than companies with little R&D or no R&D.

Hall & Oriani (2006) researched 'Does the market value R&D investment by European firms? Evidence from a panel of manufacturing firms in France, Germany, and Italy'. They wanted to bridge the gap between the research that was already done mainly on the USA or OECD countries, by researching continental European countries. They found that the value of R&D in the markets of France and Germany are similar to those of the UK and the USA, where R&D is valued by the financial markets. And that R&D in Italy is not valued by the financial markets.

Fedyk et al (2018) performed a longitudinal study on R&D investments and firm performance, their study shows that long term underinvestment into R&D investments will lead to poor performances in the future.

Eberhart et al (2004) examined the effects of long-term abnormal stock returns and operating performance after the R&D expenditure was increased significantly. They researched firms for the period of 1951 until 2001on a total of 3148 firms. Their data is on American firms. They found that if the R&D expenditure increased so did the abnormal return margins for these firms.

Booltink & Saka-Helmhout (2017) investigated the relationship between R&D intensity and performance for non-high-tech SMEs (Small & medium sized enterprises). They argued the standpoint that R&D is seen as a constraint for non-high-tech SMEs. In their research they found that if the R&D investments reaches a certain threshold it can lead to better performances. The research was performed on European SMEs. Indicating towards a U-shaped relationship.

Quo et al (2004) and Vithessonthi et al (2016) both found a negative relationship between RDI investments are a company's financial performance. Quo's research was on the Chinese software industry and Vithessonthi research was on non-financial US stock listed firms.

Lome et al (2016) did research on the R&D and its subsequent impact on firms' performance. The data was construed with 247 manufacturing firms from Norway. The special element of this study is that it researched the impact of R&D on performance during a financial crisis. They found that there is a positive relationship between R&D and a firms' performance but that it even gets accentuated during a financial crisis, further stressing the importance of research and development.

Bae et al (2008), performed a study on R&D intensity and firm performance. The sample consisted of manufacturing companies from The United States of America. In their studies they found a S shaped relationship, meaning that in the early stages R&D causes for a negative relationship and in the middle stages causes for a positive relationship, that in the last stages goes negative again.

2.2 High-tech versus non-high-tech

The term high-tech refers to the use of the most advanced and developed machines and methods. When industries are referred to as low-tech it means that the companies in that industry are not using the most recent equipment and methods (Mirriam-Webster, 1964). Furthermore, for this study a distinction is made between high-tech and non-high-tech from the Eurostat classification for technological industry (Eurostat, 2008).

In the existing literature the separation between high-tech and non-high-tech is not often made. Which can cause bias in the data from these studies, because as mentioned before high-tech companies tend to invest more into R&D than its non-high-tech counterpart. This may cause that the data in those research papers are skewed. Because of the overrepresentation of high-tech investment as compared to non-high-tech companies. Therefore, in this study the decision to distinguish between technologies has been made to try and more precisely indicate the impact of R&D investments on companies' financial performances operating in the G8 market.

Nunes et al (2012) have researched whether there is a linear relationship between R&D intensity and growth. The data solely consist of SMEs. This research is done in a manner that compares the results of high-tech to non-high-tech SMEs. The data ranges from 1999 until 2006 on Iberian SMEs. R&D intensity restricts high-tech companies' growth at a lower level and stimulates it at high levels. R&D intensity at non-high-tech companies were considered to be solely restricting.

Deeds (2001) analyzed R&D intensity in high-tech companies. The data is retrieved from companies that went public between 1982 and 1993, in the field of pharmaceutical biotechnology. Pharmaceutical biotechnology is considered high-tech. With the data a correlation matrix and a subsequent regression analysis was made. Consequently, resulting in a positive relationship between the R&D intensity and the high-tech pharmaceutical biotechnology companies.

A large research on 1809 US and European firms about productivity gains from R&D investments from 1990-2008. The data was retrieved from manufacturing and service firms. The main findings of this study were that there is a positive relationship between R&D investments and productivity, more interestingly they found that this impact on productivity is bigger from high-tech sectors than it is for non-high-tech sectors (Ortega-Argilés et al 2011).

All concluding the previous literature is mixed with negative and positive impact from the research and development investments aiding in a firm's financial performance. Also in this chapter the hypotheses will be presented.

2.3 Hypothesis Development

The research will be based around two hypotheses. Using previous research from the earlier sections. The first hypothesis will be line with these research papers (Anagnostopoulou et al & Ebenhart et al & Lome et al). The first hypothesis is about the positive impact of R&D investments on financial performance. Non-linearity will be added to the first hypothesis, because logically a company can't endlessly spend on research and development. Research and development brings it positive impact by innovation new products/processes and outperforming your competitors with the new products/processes, but research and development also costs money. Research and development can then cause for a competitive advantage, but competitors will eventually catch on to the new technology and try to implement it themselves and for less costs than the first mover. So, with the previous papers and

TABLE 1: DEFINITION OF VARIABLES

Variables	Definition
Dependent variables	
Return on assets	Net income divided by total assets
Return on equity	Net income divided by total equity
Profit margin	EBIT divided by operating income
Independent variables	
Research and development intensity	R&D costs divided by sales
R&D intensity squared	Squared function of RDI
Control variables	
Leverage	Long-term debt divided by total assets
Size	Logarithm of annual revenues
High tech dummy	1 for high tech, 0 for non-high tech
Industry control high tech	Companies with code Rev.2 26 are 1. Rev.2 21 are 0
Industry control non high tech	Medium and medium high tech are 1, low technology is 0.

the notion of the impossibility for endless spending on R&D the first hypothesis is drawn.

Hypothesis 1: Research and development investments positively impacts financial performance in a non-linear way

However, because this research specifically differentiates between high-tech and non-high-tech. Reviewing the previous research on the differentiation between the technologies (Booltink et al & Ortega-Argilés et al), the second hypothesis is drawn.

Hypothesis 2: Research and development investments have more impact on high-tech companies as compared to non-high-tech companies.

The hypotheses will be tested with a regression analysis and the conclusion will be drawn on which hypotheses will be accepted or rejected.

3. METHODOLOGY

In this chapter the independent, dependent and independent variables as well as the research model will be presented. These will be split into two sections. In table 1 the definition of the variables is given.

3.1 Variables

The impact of research and development investments on financial performance is measured in this research differentiating between high-tech and non-high-tech companies and in the split samples with industry control. In this research there are two independent variables that are tried to be explained by three dependent variables and controlled by four variables.

3.2 Independent Variables: Research and Development Intensity & RDI squared

The independent variable or sometimes referred to as the explanatory variable in this research model is: Research and development investments. Research and development investment levels will be measured with help of the Orbis database. The variable chosen to represent research and development investments is research and development intensity as other researchers have done before (Lome et al & Nunes et al & Yeh et al & Ehie et al). Research and development intensity (RDI) is measured through the R&D costs divided by the sales of the firm. That makes it an index variable, that can be read like reading percentages. To check for a non-linear relationship between RDI and company's financial performance, the squared function of the RDI is added. If the RDI is positive but the RDI squared negative than that would indicate an inverted U shape relationship or at least a bend in the line. To check and see what type of relationship would be best suited for this study a SPSS curve estimation will be performed and from there the type of relationship will be chosen and whether or not the RDI squared will stay in the research model. The RDI squared will only be kept in the model if the curve estimation indicates towards a quadratic relationship.

3.3 Dependent Variables: Return on assets & Return on equity & Profit margin

The dependent variables are influenced by the independent variable(s), in this research that is research and development investments. The dependent variable is a firm's financial performance. However, a firm's financial performance is a variable that is hard to encapsulate into a single variable. That is why this variable is broken up into three different metrics that all provide information on a firm's financial performance. The three dependent variables that are chosen are: Return on assets (ROA)(Vinthessonthi et al, 2016), return on equity (ROE)(Yeh et al, 2010), and Profit margin (PM)(Anagnostopoulou et al & Booltink et al). Return on assets is generated through net income divided by total assets. The ROA shows how well a firm is able to turn its assets into profits. Return on equity is given through net income divided by a firm's equity. The ROE highlights how a firm's profits compare to its equity. The ROA and the ROE are different in the fact that the first does take debt into its calculations and the latter does not. Also, the ROA differentiates itself from the ROE with that it focuses on the total firm, and thus gives a more general view of the total firm's financial performance. The third dependent variable is profit margin. The profit margin is calculated through dividing the earnings before interest and tax (EBIT) by the operating income. These three variables together make up the firm's financial performance in the research equation of this research.

3.4 Control Variables: Size & Leverage & Dummy & Industry control

Four control variables are chosen: Size (SIZE)(Lome & Nunes & Yeh), leverage (LEV)(Gharbi,2014), High-tech dummy(Aggelopoulos, 2016), and the industry control (Booltink & Saka, 2015). Size is a control variable that is calculated through the logarithm of annual revenues. Firm size is an important factor when considering the ability of companies to invest in research and development. Larger companies could invest more into R&D than smaller companies, since larger companies tend to have more resources readily available to invest. Therefore, the logarithm of annual revenues as size has been chosen to control size and its influence on a company's financial performance. Leverage is calculated through dividing total debt by total assets. The higher this ratio becomes the more 'leveraged' a firm is. This control variable is used by more studies as a controlling variable (Ghabri et al & Nunes et al). Leverage is used to determine how much of a firm's assets are financed through debt. The third variable is a dummy variable. Dummy variables have dichotomous values, meaning that in this research they are either 0 or 1. 0 is the value given to the non-high-tech companies and 1 for the companies that are high-tech (Booltink et al, 2017). For the split samples industry control will be a control variable. So, for the main research of this study the high-tech dummy is used and for the high-tech and non-high-tech split samples industry control is used. For the high-tech sample that means that all NACE rev.2 codes starting with 21(Manufacture of basic pharmaceutical products and pharmaceutical preparations) is indicated as 0 and with 26(Manufacture of computer, electronic and optical products) indicated as 1. For the non-high-tech split the division is 1 for companies in medium high and medium technology industries and 0 for companies in low technology industries.

3.5 Research Model on the impact of R&D Investments on Financial Performance

The purpose of this model is to examine if there is a relationship between research and development investments and a firm's financial performance. The model that is built for this research will be analyzed through a regression. Because the data from Orbis is carefully selected that each R&D year is accounted for, the data is strongly balanced and large. Meaning that the data is turned into panel data. From panel data a model can be set up in order that investigate the relationship between the dependent variables and the explanatory variables. The model in this research is based around nine variables in total: two independent, three dependent, and four control variables. A curve estimation test was performed, and it indicated towards a quadratic relationship between the independent variable and the three dependent variables individually. The ROA curve estimation is for linear 0.008 to for quadratic 0.035. The ROE curve estimation is for linear 0.025 to for quadratic 0.03 and lastly for PM the curve estimation is for linear 0.001 to for quadratic 0.033 these changes are in R square. There are quite big improvements with the ROA and PM and still improvement for ROE but less than the others. It is therefore chosen to include the RDI squared into this research. The full curve estimation results are shown in the Appendix D. The model is based on a firm's financial performance. The firm's financial performance is

$$\textit{Model (1):} Firm's\ financial\ performance_{it}(Y) = \beta_1(RDI)_{it} + \beta_2(RDI^2)_{it} + \beta_3(SIZE)_{it} + \beta_4(LEV)_{it} + \beta_5(D)_{it} + \varepsilon_{it}$$

In order to run regression sufficiently it important to take into account the assumptions that a regression brings with itself. In order to check for autocorrelation and multicollinearity issues, a VIF test was performed which had a score under 10.

Model (2) is for the high-tech split. The high-tech dummy is replaced by the industry control for different high-tech industries is introduced, leading to the following change in the model.

$$\textit{Model (2):}\ Firm's\ financial\ performance_{it}(Y) = \beta_1(RDI)_{it} + \beta_2(RDI^2)_{it} + \beta_3(SIZE)_{it} + \beta_4(LEV)_{it} + \beta_5(Industry\ control\ high - tech)_{it} + \varepsilon_{it}$$

Model (3) is for the non-high-tech split. The industry control for medium-high/medium and low technology is added. Leading to model (3).

$$\textit{Model (3):}\ Firm's\ financial\ performance_{it}(Y) = \beta_1(RDI)_{it} + \beta_2(RDI^2)_{it} + \beta_3(SIZE)_{it} + \beta_4(LEV)_{it} + \beta_5(Industry\ control\ non - high - tech)_{it} + \varepsilon_{it}$$

The i in each model represents the individual company and t represents each of the years investigated in this study. ε represents the unobserved random error in the dependent variables. Note that in all tables the RDI^2 is named RDI SQ. That is done for aesthetic reasons, so that the tables rows like the same and it is easier to read.

3.6 Robustness check

In order that check whether result brought upon by the regression are rightly interpreted a robustness check will be performed with lagged explanatory variables. It is widely believed that research and development investments need time to catch up with their costs and turn into a profit. The independent variable will be lagged by 2 years. So, for example the return on assets from 2016 will be matched with the research and development intensity of 2014.

4. DATA

The distinction between high and non-high tech is made upon guidelines provided by the Eurostat. 'Eurostat indicators on High-tech industry and Knowledge – intense services'. See appendix B for the distinction between industries. To further investigate in the different industries a complete list of the NACE rev.2 industries will be put in the references. (Eurostat, 2008)(Eurostat, 2008)

4.1 Data Collection

All data on G8 companies was found with the help of the Orbis database. Different industries are selected for the high-tech companies and for the non-high-tech companies with the help of the Eurostat guidelines. For the exact distinction between industries look at the Appendix B. The sample consists of 4512 companies in G8 territory. Of these 4512 companies 892 are high tech and 3620 non-high-tech. It is chosen in to only select companies that have the research and development investments available from 2014

TABLE 2: DESCRIPTIVE STATISTICS

	N	Minimum	Maximum	Mean	Std. Deviation
			Full Sample		
ROA	18048	-15.587	22.473	4.860	6.980
ROE	18048	-40.448	60.841	11.331	17.686
PM	18048	-23.564	27.722	5.379	9.034
RDI	18048	0.000	22.346	2.404	4.221
RDI SQ	18048	0.000	499.343	23.592	67.739
LEV	18048	0.000	70.676	15.612	16.454
SIZE	18048	1.877	8.596	5.262	0.926
			Hightech Sample		
ROA	3568	-15.587	22.473	4.462	8.796
ROE	3568	-40.448	60.841	8.152	19.541
PM	3568	-23.564	27.722	5.507	11.982
RDI	3568	0.000	22.346	6.736	6.355
RDI SQ	3568	0.000	499.343	85.746	117.694
LEV	3568	0.000	68.043	11.478	14.116
SIZE	3568	2.223	8.369	5.363	0.933
			Non Hightech Sample		
ROA	14480	-15.587	22.473	4.959	6.452
ROE	14480	-40.448	60.841	12.114	17.108
PM	14480	-23.564	22.722	5.348	8.146
RDI	14480	0.000	18.604	1.337	2.548
RDI SQ	14480	0.000	346.12	8.2767	2.548
LEV	14480	0.000	70.676	16.631	33.472
SIZE	14480	1.877	8.596	5.237	0.922

Note: Std. Deviation is standard deviation, all variables as defined in table 1. ROA, ROE, PM, RDI & LEV are measured in percentages.

until 2017. The data is winsorized at 2.5^{th} and at the 97.5^{th} percentile. To mitigate the effects the extreme values would have on this research. Each year analyzed is counted towards N, which ends up being 3568 for the high-tech sample and 14480 for the non-high-tech sample, and in total equaling to 18048 units analyzed. To see to what extent a country is represented in the study look at the Appendix A where the numbers of companies are provided as well as the percentages. The industry control will be added in the split samples for the high tech a value of 1 accounts for 721 coompanies out of 892 (80.8%) and a value of 0 accounts for 171 companies (19.2%). For the non-high-tech companies the medium-high/medium technology companies account for 2399 companies out of the 3620 (66.3%) and a value of 0 for the low-tech companies equals to 1221 companies (33.7%).

4.2 Descriptive Statistics

The descriptive statistics are provided in three-fold. The full sample, high-tech sample and non-high-tech sample are presented in table 2. In the full sample 18048 units are measured. The high-tech sample is measured with 3568 units and the non-high-tech sample is measured with the remaining 14480 units. The maxima and the minima for the company's financial performance are extremely similar across all three samples. The return on assets shows a negative minimum value of -15.587% and a maximum positive value of 22.473%. The mean from the full sample is 4.860% that means that the average return on assets in the study is 4.860%. The mean between both samples are relatively similar too, with 4.462% for the high-tech sample and 4.959% for the non-high-tech sample. But the standard deviation between the two samples is different. 8.796% and for the high-tech sample 6.452% that means that it is more likely to see return on assets ratios deviate more from the mean in the high-tech sector than it is for the non-high-tech sector. The return on equity ratio in all three samples has a higher standard deviation that its mean. Indicating that is a relatively large set of ratios that would fall in the normal distribution curve and not be outliers. The mean of the ROE is 11.331% meaning that the average company in this sample makes a net income of about roughly $1/10^{th}$ compared to its equity. The means and standard deviations between the split samples are different in that the non-high-tech companies on average have a higher ROE and less standard deviation than the high-tech sample. The profit margin shows a minimum of 23.564% and a maximum of 27.722%. The profit margin is calculated through the earnings before interest and tax divided by the operating income. The means are similar across all the samples. However, the standard deviation from the high-tech sample (11.982%) is higher than it is for the non-high-tech sample (8.146%). Meaning that similar to the ROA it is more likely to see the high-tech companies with deviating values from the mean and still be considered normal. Research and development intensity highlight the differences between the split samples. The high-tech sample has a mean of 6.736% and the non-high-tech sample records a mean of 1.337%. That means that percentages-wise the high-tech companies on average spend five times as much on research and development as compared to sales than the non-high-tech sample. There is also a big gap between both standard deviation with the high-tech sample indicating a much bigger standard deviation than the non-high-tech sample.

TABLE 4: REGRESSION FULL SAMPLE

	ROA			ROE			PM		
Model	1a	1b	1c	1a	1b	1c	1a	1b	1c
RDI		-0.296*** (-21.053)	0.077** (1.981)		-0.772*** (-21.438)	-0.353*** (-3.547)		-0.274*** (-14.988)	0.344*** (6.624)
RDI SQ			-0.024*** (-10.307)			-0.026*** (-4.510)			-0.038*** (-12.941)
H-T-D	-0.990*** (-7.773)	0.544*** (3.743)	0.399*** (2.742)	-3.744*** (-11.457)	0.264 (0.707)	0.101 (0.269)	-0.407** (-2.467)	1.016*** (5.365)	0.780*** (4.115)
LEV	-0.058*** (-18.914)	-0.065*** (-21.126)	-0.061*** (-19.665)	0.114*** (14.354)	0.097*** (12.352)	0.102*** (12.841)	-0.057*** (-14.311)	-0.063*** (-15.806)	-0.056*** (-14.058)
SIZE	1.522*** (27.912)	1.764*** (31.888)	1.571*** (27.255)	2.924*** (20.887)	3.528*** (25.007)	3.322*** (22.418)	2.150*** (30.431)	2.365*** (32.997)	2.066*** (27.556)
Constant	-2.043*** (-6.824)	-2.753*** (-9.248)	-2.168*** (-7.172)	-5.090*** (-6.625)	-6.946*** (-9.096)	-6.287*** (-8.090)	-4.961*** (-12.792)	-5.620*** (-14.487)	-4.664*** (-11.862)
R^2	6.4	8.7	9.2	4.0	6.4	6.5	6.3	7.4	8.3
Adj. R^2	6.4	8.7	9.2	4.0	6.4	6.5	6.2	7.4	8.2

Note: asterisks ***, **, * represent 1, 5, 10% significance level. H-T-D is short for high tech dummy. Number of observations are 18048.

Leverage shows how much a company is financed through debt. In this study the average company is leveraged up to about 15.612%. The non-high-tech sample mean is higher than that for the high-tech sample. 16.631% and 11.478%. However, the key difference between the samples lies within the standard deviation. The standard deviation is more than twice as large for the non-high-tech companies as it is for the high-tech companies. Showing that is more normal to higher or lower values in the non-high-tech samples. Size is similarly spread across the samples. Size is measured through the logarithm of annual revenues it is therefore not of value to interpret it from the descriptive statistics.

5. RESULTS

In this section the results are discussed by firstly investigating the correlation matrix of the full sample. Table 3 depicts the Pearson correlation of the full sample. The asterisks ***, **, * mark 1%, 5%, 10% significance levels respectively. H-T D is short for the high-tech dummy that indicated if a company in the sample belongs to the high-tech industry or not. The dependent variables are all strongly significant with each other. With positive values, which in logical terms is self-evident. Research and development intensity is negatively correlated to all dependent variables in this study. Which, from looking at the curve estimations in the Appendix D, makes sense, because all linear estimators are negative. The correlation looks for a linear relationship. The values of RDI probably only have a positive impact on a company's financial performance in lower levels of RDI, after that it becomes restricting for a company's financial growth. Most of the graph will then be in the negative, meaning that from the correlation it shows a negative value. Leverage shows a negative value for two out of the three dependent variables. ROA and PM. Leverage is also negatively correlated with RDI, SIZE and the high-tech dummy. Leverage is only positively correlated to the ROE. Size shows a significant positive relationship with all three dependent variables. It also has a significant positive relationship with RDI and a negative relationship with leverage. The high-tech dummy is significant in against almost every variable in this study apart from PM.

TABLE 3: PEARSON CORRELATION FULL SAMPLE

	ROA	ROE	PM	RDI	RDISQ	LEV	SIZE	H-T D
ROA	1							
ROE	0.824***	1						
PM	0.882***	0.695***	1					
RDI	-0.91**	-.0158***	-0.037***	1				
RDI SQ	-0.141***	-0.173***	-0.096***	0.940***	1			
LEV	-0.147***	0.104***	-0.120***	-0.159***	-0.101***	1		
SIZE	0.210***	0.140***	0.228***	0.205***	0.091***	-0.083***	1	
H-T D	-0.028***	-0.089***	0.007	0.509***	0.455***	-0.125***	0.054***	1

Note: number of observations are 18048. The asterisks ***, **, *. Are 1%,5%, 10% significance level respectively. H-T D is short for high tech dummy.

TABLE 6: REGRESSION HIGH-TECH SAMPLE

	ROA			ROE			PM		
Model	1a	1b	1c	1a	1b	1c	1a	1b	1c
RDI		-0.299*** (-13.417)	0.045** (0.565)		-0.725*** (-14.703)	-0.452** (-2.548)		-0.294*** (-9.706)	0.266** (2.453)
RDI SQ			-0.019*** (-4.481)			-0.015 (-1.604)			-0.031*** (-5.374)
IND-H	-0.715*** (-1.990)	-1.397*** (-3.942)	-1.490*** (-4.208)	-1.032 (-1.292)	-3.425*** (-3.425)	-2.759*** (-3.514)	-2.146*** (-4.444)	-2.817*** (-5.487)	-2.968*** (-6.175)
LEV	-0.074*** (-7.283)	-0.085*** (-8.550)	-0.081*** (-8.159)	0.036 (1.604)	0.009 (0.426)	0.012 (0.562)	-0.076*** (-5.609)	-0.087*** (-6.468)	-0.081*** (-6.009)
SIZE	2.683*** (17.475)	3.058*** (20.067)	2.878*** (18.298)	5.913*** (17.323)	6.823*** (20.234)	6.679*** (19.150)	4.147*** (20.101)	4.516*** (21.797)	4.221*** (19.772)
Constant	-8.502*** (-9.500)	-7.822*** (-8.942)	-7.499*** (-8.567)	-23.139*** (-11.630)	-21.492*** (-11.105)	-21.235*** (-10.938)	-14.120*** (-11.743)	-13.452*** (-11.313)	-12.926*** (-10.876)
R^2	8.6	13.0	13.5	8.4	13.7	13.7	11.0	13.3	14.0
Adj. R^2	8.5	12.9	13.3	8.4	13.6	13.6	11.0	13.2	13.9

Note: asterisks ***, **, * represent 1, 5, 10% significance level. IND-H is short for Industry control. Number of observations are 3568.

5.1 Research & Development Investment on companies' financial performances

Table 4 represents the regression results for the full sample. The regression is split up into three different models for every dependent variable. Model 1a contains only the control variables, Model 1b contains the control variables and RDI and Model 1c contains every variable investigated in this study. In all three models all control variables are significant at the 99th percentile. Size always has a positive impact on the ROA. Meaning that the bigger a company the more likely it is that they will have a higher ROA. The opposite is true for LEV. Leverage is negatively correlated with ROA. Meaning that companies that finance their operations with more debt than other companies would have a lower ROA. The high tech dummy is also significant at the 99th percentile for all models. However, from Model 1a to 1b and 1c it changes from a negative value to a positive value. With relevance to this study it means that high-tech companies are more likely to have a higher ROA, whilst the mean is lower for high tech companies, but the standard deviation is bigger. In Model 1b where the RDI is first introduced it has a negative impact on the ROA. RDI has a negative value of -0.296 that would mean that every percentage put into R&D by a company would lead into -0.296% in ROA. However, in Model 1c where the RDI squared is also introduced a better relationship can be seen. The RDI changes to a positive value of 0.077 and the RDI shows a negative value of -0.024 indicating towards an inverted U-shape relationship. Model 1a has a R squared value of 6.4, Model 1b has a R squared value of 8.7 and Model 1c has a R squared value of 9.2. Highlighting that every value added was of value for the variance shown in ROA. The ROE shows similar patterns with SIZE and LEV both are in all three models significant at the 99th percentile and SIZE is positive, and LEV is now also positive. It is quite logical to see that LEV becomes positive with regards to the ROE, because the more leverage it has thus comparatively less equity the ROE percentages can be higher easier. The high-tech dummy only showed a negative significant value in Model 1a and a positive insignificant value in Model 1b & 1c. That indicated towards that there is not much difference in the return on equity between high-tech and non-high-tech companies. Interestedly, in Model 1b&c the RDI stays significantly negative, meaning that there is a negative relationship between research and development investments and return on equity of that year. Similar to the R squared changes in the ROA regression, in the ROE regressions the R square changes are also positive with the inclusion of each new variable. Model 1c shows a R squared value of 6.5. Profit margin closely resembles the ROA. SIZE is significantly positive and LEV again is significantly negative. The high-tech dummy jumps from a positive value in Model 1a to negative values in Models 1b&c. The R square also showed positive changes with the progression of the Models again ending up with an 8.3.

5.2 High-tech versus non-high-tech

In this section the differences between the high tech and non-high-tech samples will be analyzed and described. Table 5 depicts the Pearson correlation for both the split samples. Table 6&7 are the regression for the high-tech split and the non-high-tech split, respectively. The models used in this regression are the same as those used in the analysis of the full sample regression. Starting from the ROA in Model 1a similar positive and negative variables are found. However, their coefficients are not similar. SIZE has more than twice the impact on the high-tech companies than it does on non-high-tech companies. Also the R squared value of the high-tech sample is larger in every model. In Model

TABLE 7: REGRESSION NON-HIGH-TECH SAMPLE

	ROA			ROE			PM		
Model	1a	1b	1c	1a	1b	1c	1a	1b	1c
RDI		-1.175*** (-3.713)	0.287*** (5.932)		-0.969*** (-16.958)	0.165 (1.256)		-0.344*** (-12.800)	0.640*** (10.438)
RDI SQ			-0.051*** (-14.463)			-0.092*** (-9.566)			-0.080*** (-17.796)
IND-NH	0.123 (1.111)	0.219** (1.998)	0.018 (0.164)	-0.335 (-1.118)	-0.064 (-0.215)	-0.425 (-1.424)	0.737*** (5.264)	0.833*** (5.974)	0.520*** (3.739)
LEV	-0.060*** (-19.228)	-0.067*** (-21.498)	-0.062*** (-19.965)	0.115*** (13.663)	0.095*** (11.281)	0.104*** (12.282)	-0.061*** (-15.321)	-0.068*** (-17.050)	-0.060*** (-15.216)
SIZE	1.224*** (21.476)	1.445*** (-21.498)	1.157*** (18.977)	2.231*** (14.470)	2.853*** (18.170)	2.337*** (14.116)	1.597*** (22.145)	1.817*** (24.644)	1.370*** (17.754)
Constant	-0.533** (-1.682)	-1.175*** (-3.713)	-0.038 (-0.117)	-1.267*** (-1.477)	-3.075*** (-3.593)	-1.033* (-1.175)	-2.497*** (-6.227)	-3.138*** (-7.808)	-1.368*** (-3.337)
R^2	6.3	8.0	9.3	2.4	4.3	4.9	5.8	6.9	8.9
Adj. R^2	6.3	7.9	9.2	2.4	4.3	4.9	5.8	6.9	8.9

Note: asterisks ***, **, * represent 1, 5, 10% significance level. IND-NH is short for Industry control. Number of observations are 14480.

1c the high-tech R squared is 13.5% whilst the non-high-tech sample has a R squared value of 9.2%. LEV is strongly significant in both samples but for the high-tech sample slightly more so. In Model 1b the coefficient from the non-high-tech sample for RDI is larger, indicating that it research and development investments impact non-high-tech companies more negatively than it does for high-tech companies. In Model 1c both samples show a significantly positive RDI and RDI SQ indicating that both show an inverted U-shape relationship. The coefficients for the high-tech sample are lower meaning that it RDI investments has less impact than on non-high-tech companies. The industry control dummies show that it negatively impacts the high-tech sample and positively impacts the non-high-tech sample meaning in the case of the latter that low-technology companies would see a higher ROA, but this result is insignificant.

Investigating the ROE of both samples it can be deducted that again SIZE is more important to a high-tech company than for a non-high-tech company although both are strongly significant. The R squared value of the high-tech sample is also higher than that of the non-high-tech sample. In Model 1c they show 13.9% and 4.9% respectively. Similar to the full sample regression LEV becomes positive in the ROE regression. However, what is interesting to note is that in the high-tech sample LEV is positive but always insignificant whilst it is always strongly positively significant in the non-high-tech sample. Both samples their Industry control are significant for the high-tech sample negative meaning that computer manufacturers would on average report a lower ROE than manufacturers of pharmaceuticals and low-technology companies on average see a better ROE than the medium/medium-high technology companies. Both coefficients for RDI are significantly negative in Model 1b. Like in Table 4 where the full regression is depicted the profit margin shows similar positives and negatives to that of the ROA. In both samples LEV negatively impacts the PM but for the high-tech sample slightly more so. SIZE again is more important for the high-tech companies than for the non-high-tech companies. The industry control dummy is positive for the non-high-tech sample and negative for the high-tech sample. Both coefficients in both samples for RDI show a positive value and negative value for RDI squared further validating the inverted U-shape relationship.

5.3 Calculations for optimum financial performance

Using all the formulas that can be made from the regression only using RDI and the RDI squared. Algebra can be used to see what the inverted U shape look like and what its top is and what intercepts it has. So, for all the dependent variables the formulas are ROA = -0.049x^2 + .0588x + 4.602, ROE = -0.56x^2 + 0.184x + 12.210 and PM = -0.070x^2 + 0.973x + 4.687. All the values without an X are close to the mean of that variable, that is what one would get if a company invest 0 into research and development. ROA shows it biggest value if the RDI is 6%, namely 6.366%. Every percentage spend into research and development up until 6 has a positive slope. After 6% until 12% there is a negative slope, but it is still above the 4.602% starting level. So, 8 would for instance be 6.17%. After the RDI reaches 17.398% the ROA becomes negative. The ROE starts off with 12.210% if RDI is 0% its highest point is reached at 1.64% with 12.361%. The slope is positive until that 1.64% is reached and becomes negative, but with a positive impact until 3.286%. ROE becomes negative after a 4.837% investment in research and development. PM starts off with 4.687% when 0% is invested in R&D. This can, however, be improved massively, by investing 6,95% into research and development as compared to sales that would increase the PM to 8.068%. Every percentage in RDI up until 6.95% has a positive slope on PM. 6.95% up until 13.9% would still have a positive impact on PM but on a negative slope. After reaching 17.686% spend in RDI the PM becomes negative. ROA and PM are both very similar in investment and return levels. Full sample percentages gained from optimum RDI level as compared to sample mean: ROA 1.764%, ROE 0.151%, PM 3.381%

The same calculation can be made in the split samples. High-tech sample: ROA= -0.039x^2 + 0.495x + 4.466, ROE= -0.058x^2 + 0.511x + 4.466 and PM= -0.059x^2 + 0.910x + 4.442. For the non-high-tech sample: ROA= -0.083x^2 + 0.835x + 4.530, ROE= -0.120x^2 + 0.584x + 12.328 and PM= -0.118x^2 + 1.284x + 4.606. ROA in the high-tech sample has a top of 6.037% with an 6.346% investment into R&D. The slope is positive up until 6.346%, still a positive impact but a negative slope from 6.346% until 12.692%. The ROA goes negative from 18.787% onwards. In the non-high-tech split. The ROA reaches a top of 6.63% at 5.03% RDI. The slope stays positive until 5.03% and goes negative, but still positive until 10.06% and the ROA gets a negative value from 13.968% onwards. ROE in the non-high-tech split is on its top at 2.43% RDI with 13.039% ROE. Slope is positive from 0 until 2.43%. The slope is negative but still has a positive impact from 2.43% until 4.867%. The ROE becomes negative at 12.857% invested in RDI. In the high-tech split the ROE reaches its top at 4.405% RDI resulting in 10.802% ROE. The slope is positive up until 4.405% and becomes negative but still positive impact until 8.81%. The ROE becomes negative from 18.055% onwards. PM in the high-tech split shows a top of 7.951% at an RDI investment of 7.712%. The slope is positive until 7.712% and becomes negative, but still positive until 15.424%. PM becomes negative from 19.312%. In the non-high-tech split, PM reaches a top of 8.099% with a 5.44% RDI investment. The slope remains positive until that point. The slope is negative, but a positive impact from 5.44 until 10.881% and PM becomes negative from 13.725%. High-tech percentages gained from optimum RDI level as compared to sample mean: ROA 1.571%, ROE 1.121%, PM 3.509%. Non-high-tech percentages gained from optimum RDI level as compared to sample mean: ROA 2.1%, ROE 0.711%, PM 3.493%. It can be concluded that up to a point RDI investment aid in a company's financial performance from these statistics. The regression results can been seen in Appendix E.

5.4 Robustness check regression

In Table 8 the lagged regression is shown. This table is shown in the Appendix C. The lagged regression is built on the same regression models as used previously in this research. Although the R on average are roughly 1 percentage point less and the coefficients are slightly lower. There is enough cause to confirm the findings of this study due, to similar coefficients and very high significance levels across the lagged regression. The RDI in still shows a significant positive coefficient and the RDI squared still shows a significant negative coefficient in most cases. Confirming the results found.

6. CONCLUSION

The aim of this study is to investigate the effects of research and development investments on a company's financial performance. A multitude of dependent variables are used. These variables together make up a company's financial performance. The research question of this research was "To what extent do R&D investments contribute to a firm's performance?'. The findings of this study identify a relationship between research and development investments and a firm's performance, namely an inverted U shape relationship (Booltink & Saka, 2017) (Yeh,2010). Meaning that the relationship in the beginning is increasingly positive and later becomes increasingly negatively. For the full sample that means that for the ROA, the slope is positive until 6% where its top is with a ROA score of 6.366%, from 6% on the slope becomes negative from 12% onwards RDI has a negative impact on ROA. In the ROE, RDI investments has a positive slope until 1.64% and becomes negative slope from 1.64% onwards and negatively affecting ROE after 3.286%. And lastly for the PM shows the biggest gain to be possibly gained. 3.381%. The PM shows a positive slope until 6.95% invested into RDI from there on the slope becomes negative and negatively impacting PM from 13.9%. The ROA & PM show quite similar thresholds for their RDI investment levels. Unfortunately, ROE does it at a lower level. Leading to the hypotheses: based on the evidence provided in this research hypothesis 1: *Research and development investments positively impacts financial performance in a non-linear way.* Is accepted. However, there is a side note, only up to a certain point it is positively impacting a company's financial performance. For ROA until 12%, ROE 3.285%, PM 13.9%. After these percentages the variables go under their original Y intercept, meaning a negative impact from RDI investments. The second hypothesis that is investigated in this research is: *Research and development investments have more impact on high-tech companies as compared to non-high-tech companies.* Is rejected. Because, most coefficients were larger for the non-high-tech sample, indicating a bigger impact. Showing from the percentages gained as compared to the mean. The high-tech sample has a higher percentage in two of three dependent variables (ROE & PM). Both are impacted positively by RDI investments up until a certain, but the high-tech sample not statistically more so than the non-high-tech sample. Concluding from all the models tested that included size, size is a big indicator into a company's financial performance, because it always had the biggest coefficient of all the all the variables in all the regressions. This can tie in the resource-based view that bigger companies tend to have more resource readily available to better plan for the future. Industry control for the non-high-tech sample is only really been significant for the PM. Whereas the industry control for the high-tech sample has been positive significantly in every regression model that included it. Leverage is restricting for the ROA & PM but in case of the ROE, it shows a positive relationship, which makes sense because the equity tends be less compared to the total if the leverage goes up.

6.1 Limitations

Further research into this topic could be necessary to gain a more complete view of the impact research and development investments have on a firm's financial performance. First of all, information regarding the R&D investments is scarcely available. Only practically really big companies have this information readily available. It is hard to gain good information over a number of succeeding years. Secondly, although this study is spread over four years, form 2014 until 2017, it might be necessary to perform a longitudinal study over a much longer period than this, in order to see whether the effects of research and development investments pay off over a longer period of time. The lagged variable could be extended over a longer period of time. Thirdly, more data on this topic should be required to be provided by companies so analyst can make better decisions. With more data available it would be easier to draw conclusions based on country level, but with so few companies making this information publicly available it is hard to draw conclusion that are significant on country level, due to small and unbalanced datasets.

7. ACKNOWLEGDEMENTS

I want to thank my supervisors; Dr. Huang & Prof. Kabir for their continuing support for this thesis and my family for sticking with me during the writing process of this thesis.

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Appendix A

G8 companies per country: high-tech split and non-high-tech split

Country	High tech	Non high tech
Canada	31 (3.5%)	141 (3.9%)
Germany	64 (7.2%)	190 (5.2%)
France	43 (4.8%)	129 (3.6%)
United Kingdom	70 (7.8%)	252 (7%)
Italy	14 (1.6%)	81 (2.2%)
Japan	333 (37.3%)	2184 (60.3%)
Russian Federation	34 (3.8%)	242 (6.7%)
United States of America	303 (34%)	401 (11.1%)
Total	892 (100%)	3620 (100%)

Appendix B

Industry control clarification

High tech: rev.2 26 & 21

21 Manufacture of basic pharmaceutical products and pharmaceutical preparations

26 Manufacture of computer, electronic and optical products

Medium-high tech: rev 2. 20, 27, 28, 29 &30

20 Manufacture of chemicals and chemical products;

27Manufacture of electrical equipment;

28Manufacture of machinery and equipment n.e.c. ;

29Manufacture of motor vehicles, trailers and semi-trailers;

30 Manufacture of other transport equipment

Medium tech: rev. 2. 19, 22, 23, 24, 25 & 33

19 Manufacture of coke and refined petroleum products

22 Manufacture of rubber and plastic products;

23 Manufacture of other non-metallic mineral products;

24 Manufacture of basic metals;]

25: Manufacture of fabricated metals products, excepts machinery and equipment

33 Repair and installation of machinery and equipment

Low tech: rev2. 10,11,12,13,14,15,16,17,18,31 &32

10 Manufacture of food products

11 Manufacture of beverages

12 Manufacture of tobacco products

13 Manufacture of textile

14 Manufacture of wearing apparel

15 Manufacture of leather and related products

16 Manufacture of wood and of products of wood

17 Manufacture of paper and paper products

18 Printing and reproduction of recorded media

31 Manufacture of furniture

32 Other manufacturing

Appendix C

TABLE 8: REGRESSION LAGGED SAMPLE

	ROA			ROE			PM		
Model	1a	1b	1c	1a	1b	1c	1a	1b	1c
RDI		-0.338*** (-23.059)	0.080** (1.999)		-0.732*** (-19.436)	-0.349*** (-3.431)		-0.261*** (-14.436)	0.351*** (6.890)
RDI SQ			-0.025*** (-10.600)			-0.021*** (-4.700)			-0.036*** (-12.447)
H-T-D	-0.897*** (-7.865)	0.598*** (3.8432)	0.397*** (2.732)	-3.452*** (-9.234)	0.261 (0.704)	0.099 (0.223)	-0.501** (-2.895)	1.004*** (5.412)	0.630*** (3.993)
LEV	-0.060*** (-19.324)	-0.070*** (-23.423)	-0.059*** (-19.320)	0.111*** (13.123)	0.100*** (13.504)	0.104*** (9.865)	-0.060*** (-12.001)	-0.064*** (-15.921)	-0.055*** (-13.048)
SIZE	1.456*** (26.512)	1.832*** (31.432)	1.498*** (27.964)	2.867*** (20.329)	3.498*** (25.367)	3.605*** (24.818)	2.201*** (30.670)	2.365*** (34.002)	2.081*** (27.612)
Constant	-2.342*** (-6.932)	-2.843*** (-9.675)	-2.269*** (-7.361)	-5.001*** (-6.436)	-6.531*** (-9.147)	-6.432*** (-8.463)	-4.741*** (-11.993)	-5.599*** (-13.783)	-4.932*** (-12.512)
R^2	6.3	8.4	9.1	3.8	6.6	6.7	6.0	7.2	8.5
Adj. R^2	6.3	8.4	9.1	3.8	6.6	6.7	6.0	7.2	8.5

Note: asterisks ***, **, * represent 1, 5, 10% significance level. H-T-D is short for high-tech dummy. Number of observations are 17064.

Appendix D

Curve estimation ROA

Equation	R squared	F	Significance	Constant	B1	B2
Linear	0.008	150.581	0.000	5.222	-0.150	
Quadratic	0.035	322.844	0.000	4.602	0.588	-0.049

Curve estimation PM

Equation	R squared	F	Significance	Constant	B1	B2
Linear	0.001	25.187	0.000	5.571	-0.080	
Quadratic	0.033	310.640	0.000	4.687	0.973	-0.070

Curve estimation ROE

Equation	R squared	F	Significance	Constant	B1	B2
Linear	0.025	460.842	0.000	12.920	-0.661	
Quadratic	0.030	291.664	0.000	12.210	0.184	-0.056

Appendix E

TABLE 9: REGRESSION INDEPENDENT SOLO

	FS			HT			NHT		
Ind Var	ROA	ROE	PM	ROA	ROE	PM	ROA	ROE	PM
RDI	0.588*** (16.585)	0.184*** (2.049)	0.973*** (21.191)	0.495*** (6.168)	0.511** (2.864)	0.910*** (8.288)	0.835*** (18.843)	0.584*** (4.927)	1.284*** (23.040)
RDI SQ	-0.049*** (-22.161)	-0.056*** (-9.998)	-0.070*** (-24.398)	-0.039*** (-8.984)	-0.058*** (-6.016)	-0.059*** (-9.963)	-0.083*** (-24.627)	-0.120*** (-13.326)	-0.118*** (-27.761)
R^2	3.5	3.0	3.3	4.2	3.8	3.2	4.3	2.7	5.1
Adj. R^2	3.5	3.0	3.3	4.1	3.8	3.2	4.3	2.7	5.1

Note: asterisks ***, **, * represent 1, 5, 10% significance level. FS > full sample HT> high tech > NHT > non high tech.
Number of observations FS 18048, HT 3568, NHT 14480