The effects of R&D investment on firm performance

Author: Bart Beld
University of Twente
P.O. Box 217, 7500AE Enschede
The Netherlands

ABSTRACT,
This study studies the effects of R&D investment on firm performance. Firm performance is measured in financial performance and market-based performance. Among (formerly) publicly listed companies from the Netherlands, Belgium and Luxembourg data is used. Extra attention is paid to the manufacturing companies in comparison with the non-manufacturing companies. The financial firm performance is positively affected by R&D investments. Significant results are found for the financial performance, the Return on Assets. The findings of the price-to-book ratio are insignificant. Differences for manufacturing and non-manufacturing companies are insignificant with the used data and not consistent over the financial and market-based performances.

Supervisors:
Prof. Dr. M.R. Kabir
Dr. X. Huang
H. C. Van Beusichem

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1. INTRODUCTION

The Netherlands has spent almost €13 billion on Research & Development in 2012. This is an amount of €772.6 per inhabitant. In the business enterprise sector a total of €7.3 billion is spent. In comparison with the previous year, 2011, an increase of 7.2 percent is seen.[1] The R&D expenditure is also expressed as a percentage of the gross domestic product (GDP), in 2012 this is 2.16%. The GDP is the sum of the total gross added values by businesses and government in one year, all produced goods and provided services expressed in money. The Dutch government set an objective of 2.5% of the GDP for 2020. The Netherlands spent more on R&D than the average in the European Union, while it's not a very big country. Why are the companies spending so much on R&D and have the government set an objective to achieve? With this information a simple conclusion can be drawn. The R&D activities are important for companies.

Research & Development are the activities a company chooses to discover new knowledge about new or existing products, processes and services. R&D investment is critical for growth, survival and success of the firm. ''Research and development is a key determinant of long-run productivity and welfare'' (Jones & Williams, 2000). The idea behind a R&D investment is to add value to the company. Franko (1989) states that the firm could enhance competitive advantage by building capabilities which the R&D investment will support. R&D spending results in new products or process efficiencies, creating competitive advantage and enhancing firm performance (Aboody & Lev, 2000).

R&D investment is an interesting topic in the existing literature, that's why a lot of studies already have done research to R&D investments. There are prior studies that researched how R&D affects the firm performance and others investigated the relationship between R&D and the market value. But most of these studies focused mainly on the OECD-countries. These countries are part of the Organization for Economic Co-operation and Development, to achieve economic progress and world trade. Most attention in the literature is paid to the companies in the United States (i. e. Le et al, 2006), the United Kingdom (i. e. Toivanen et al, 2002) and Japan (i. e. David, O'Brien & Yoshikawa, 2008).

Little information is available for R&D investments in the (continental) European countries. With the exception of the study from Hall & Oriani (2006), who focused on companies from Germany, France and Italy. The aim of this study is to give contribution to the literature, to provide more empirical evidence on the effects of R&D investment on firm performance for European countries.

The scope of my study is the Netherlands, Belgium and Luxembourg. Also familiar as the BeNeLux. The research is relevant for the literature because to my knowledge fewer studies are done to these countries. Additional to the relevance are the economies of the BeNeLux compared to the other OECD-countries. There are two differences which can lead to other relationships and solutions than the previous studies for other countries have showed, this is also confirmed by Hall & Oriani (2006).

The first difference is shown by the studies of Bond et al. (2003) and Mulkay et al. (2000). There are less financial constraints for companies in Europe in comparison with companies from the United States or United Kingdom. Without these constraints there is less pressure for results imposed by the financial capital markets. So the companies in Europe don't have to meet all the rules and results. The propensity to investment is now much higher by the less pressure. No direct results are not necessary, so long-term investment is attractive now. Another important difference is the law system. The United States and the United Kingdom have a common law system, while the Netherlands, Belgium and Luxembourg have a civil law system. The minority shareholders are less protected and the risks are bigger for external shareholders. So the common ownership structures are the concentrated ownerships. Investments might be affected by ownership structure. How much is spend on R&D investments depends on the ownership structure. Cho (1998) found that expenditures are influenced by the type of ownership.

With these two differences in legal regimes and ownership structure the firm performance could be influenced in another way to the other OECD-countries.

The research question I composed is as follows: ''What are the effects of R&D investment on firm performance''? To answer this question a panel of publicly listed companies from the Netherlands, Belgium and Luxembourg is used with a distinction between manufacturing and non-manufacturing companies. With this separation possible differences in performances could be explained by the type of industry.

In the next section a literature overview is presented and the hypotheses are given. The third section is about the methodology, the used method, variables, and data with descriptive statistics are described. After the data, the results of the data are given in the fourth section. The last section is the conclusion, where attention is given to results with the hypotheses.

2. LITERATURE REVIEW

The relationship between R&D investment and firm performance is a frequent topic in the literature. The effects of R&D investment are often investigated. Based on these prior studies some hypotheses are drawn for the research question.

2.1 R&D investment and firm performance

Investment in R&D is considered as an investment in intangible assets that contributes to the long-term growth of the firm (Chan et al, 2001). ''A successful investment in R&D results in an innovative product and services which enables the firms to enhance its intangible assets, thus differentiating itself from other firms'' (Ehie & Olibe, 2010).

Many studies on this topic did their research on firms from the United States. That's also what Eberhart, Maxwell and Siddique (2004) have done. They examined, between 1951 and 2001, firms which unexpected increase their R&D expenditures by a significant amount. With a sample of 8.313 cases the abnormal stock returns are examined as an indicator of the operating performance. In other studies multiple regression analysis customarily is used, while the Fama and French three-factor model is used by Eberthart, Maxwell and Siddique (2004). Long-term abnormal stock returns are vulnerable for incorrectly returns due to the mismeasurement of risks. For addressing this risk measurement the model of Fama and French (1993) is adopted. They find consistent evidence of significant positive long-term operating performance. The findings of their study suggest that R&D increases are beneficial investments.

Ehie and Olibe (2010) focused on the same country as Eberthart, Maxwell and Siddique (2004). But interesting in their research is the distinction made between manufacturing and

[1] Numbers of the R&D expenditure are obtained from www.eurostat.com

service companies. With a cross-sectional regression model the influence of R&D investment on the market value, a market-based performance, of the firm is examined. The results show that investment in R&D contributes positively to firm performance for both manufacturing and service firms. But differences for manufacturing and service companies are found for and after major economic disruptions (such as 9/11).

Another country which is investigated often is the United Kingdom (Anagnostopoulou & Levis, 2008). The aim of their study is to extend the prior literature on R&D and valuation by examining sustainability or persistence of operating growth and market performance as a result of R&D investments. They found evidence, from their large dataset of UK listed companies, for confirming the relationship between R&D intensity and consistent growth in sales and gross income. For the market-based performance the excess stock returns are measured. The evidence of their study shows that R&D intensity improves persistence in excess stock returns. ''The highest R&D-intensity firms are found to earn higher risk-adjusted excess returns more consistently than the sample median return, compared to lower R&D-intensity firms, as well as firms with no R&D'' (Anagnostopoulou & Levis, 2008). Just like the above mentioned studies Al-Horani, Pope and Stark (2003) found positive evidence that R&D contributes to market performance in the United Kingdom.

Hall & Oriani (2006) wanted to fill the gap of the lack of information about European countries on R&D investment. German and French samples show a statistically significant and robust positive evaluation of the R&D capital by the stock market. However, the UK sample has a greater valuation. But with these results there is some evidence that R&D valuation not differ for these European countries in an extreme way with the other OECD-countries.

Due to the above mentioned studies and evidence of positive relationship in the other OECD-countries, an increase in the R&D investment will generate profits and a better performance. But it also increase the total costs. It's also impossible for companies to spend endlessly in R&D. The innovations and processes as a result of R&D could be adopted by competitors, the sustainable advantage is now decreasing.

According to these mentioned studies and the information of endlessly spending and adoptions by competitors, my first hypothesis is as follows:

Hypothesis 1: Investment in Research & Development will affect positively the firm performance, in a non-linear way.

2.2 Manufacturing companies versus non-manufacturing companies

A manufacturing company is a business that is converting raw materials, components, or parts into finished goods that meet a customer's expectations or specifications. Nowadays the manufacturing business is not only comprised of humans. But also with big machines, robots and computers. All in a certain manner to eventually create the end product. A car manufacturer like Mercedes or a beer brewery like Heineken are examples of manufacturing companies. The non-manufacturing companies are simply said the companies that don't produce anything. These non-manufacturing companies are providing services. Therefore, non-manufacturing companies are often called service companies. Hotels and barbershops are examples of service companies.

Manufacturing companies will use the R&D activities others than non-manufacturing companies. They choose different approaches and different mixes of R&D investment because of their differences in relative orientation (Ehie & Olibe, 2010). The manufacturing companies might invest in R&D to eventually improve their production, while service companies are interested in R&D investments for other improvements.

Due to the fact that R&D can improve production and processes, the production costs can be lowered. This is also stated by Mansfield & Lee (1996). With the knowledge of the activities of a manufacturing company, the R&D activities could have a big impact on these companies in the manufacturing industry.

Ho et al. (2005) did research to R&D and advertising expenses. They made a distinction between manufacturing and non-manufacturing companies. The relationship between R&D investment and the firm performance between those industries is interesting. They found that intensive investment in R&D contributes positively to the one-year stock market performances of manufacturing companies, but not for non-manufacturing companies. They used a one-year lag because R&D investment is a variable with respect to future returns.

For a major economic disruption, such as the attack on the world trade center, the R&D investment contributes more positively to firm performance in the manufacturing sector compared to the service sector (Ehie & Olibe, 2010). After a kind of major economic disruption it is (logically) reversed. Everything needs to rebuild again. But in normal (before a disruption) the manufacturing companies will contribute more.

With this evidence and the knowledge of the activities of a manufacturing company the next hypothesis is formulated:

Hypothesis 2: Investment in Research & Development will affect the firm performance of manufacturing companies more positively than non-manufacturing companies.

3. METHODOLOGY

This section is divided into four parts. The first one describes the research method and model which is used to test the formulated hypotheses. The second part is about the variables in the research model. The data will be described in the third part. Last the descriptive statistics are presented.

3.1 Research method and model

The data from the sample is obtained for every observation, the firms, at the same time (end of year). The purpose with this data is to examine a causal relationship between R&D investment and firm performance which is also stated in the two hypotheses. This type of research is cross-sectional. Will investment in R&D affect the firm performance positively and is the firm performance of the manufacturing companies more affected? For testing these two hypotheses a multivariate regression analysis will be used. Ordinary Least Squares (OLS) regression is applied for this research. This analysis check, on the basis of correlation between the independent with the dependent variables, if there is a causal link.

3.1.1 R&D investment and firm performance

The first hypothesis is that R&D investment affects positively the firm performance, in a non-linear way. For this hypothesis the regression model is as follows:

$$\text{Firm Performance} = \alpha + \beta 1 * \text{RDI} + \beta 2 * \text{RDI}^2 + \beta 3 * \text{LEV} + \beta 4 * \text{SIZE} + \varepsilon$$

In this regression model the RDI is the R&D intensity, RDI^2 the squared term of R&D intensity, LEV is the leverage and SIZE is the firm size. The squared RDI term is deployed in order to check for a possible non-linear effect. A negative value of the parameter of squared RDI indicates a bend, so a non-linear relationship. Leverage and firm size are the so-called control variables.

α Is the constant, β are the parameters and ε is the error term. The parameters are the regression coefficients if the regression is performed. The error term is the residual, the difference between the real value of Firm performance and the predicted value of the model.

3.1.2 Manufacturing companies versus non-manufacturing companies

The firm performance of manufacturing companies is more affected by R&D investment than the firm performance of non-manufacturing companies. To test this second hypothesis the total sample is now divided into two subsamples. The same regression model is used for both the manufacturing and non-manufacturing companies. With differences in coefficients of the RDI this hypothesis is checked.

The distinction between manufacturing and non-manufacturing companies is made from the 3-digit US SIC codes. It's the Standard Industrial Classification code. Companies with a code between 200 till 399 are manufacturing companies and the companies with another code are non-manufacturing companies. These US SIC codes are obtained from the ORBIS database.

3.2 Variables

The purpose of the study is to investigate the effects of R&D investments on firm performance. Like the research question and the hypotheses also stated, the R&D investment will affect the firm performance. The predictor, the independent variable, is the R&D investment. The predicted variable, the dependent variable, is the firm performance. Also control variables are inserted to check if the firm performance is caused by these variables.

3.2.1 Independent variables

The independent variable, also called an explanatory variable, is the variable which causes something. This variable has some effects on others. In my study the independent variable is the R&D investment, the main variable of interest in my research.

The R&D intensity (RDI) is used to measure the amount of investment in Research & Development. This is a ratio of the total R&D expenditure to the total net sales of the company. Several authors stated the importance to capitalize R&D (Hirschey & Weygandt, 1985), because it represents an intangible asset (Ehie & Olibe, 2010). By capitalizing R&D the effects are equalized from the development of the investment to the end of its use. Due to the lack of an amortization rate there is no ability to capitalize R&D. So total R&D expenditure is used instead of capitalized R&D. This ratio is also widely adopted in other studies. The effects are now not equalized but are taken from the investment time, thus the development period.

3.2.2 Dependent variable

The dependent variable is a variable which is caused by others, by the independent variable(s). The dependent variable in my study is firm performance. Firm performance is a broad term and could be calculated in many ways. A distinction is made between the financial performance and market-based performance. In this study both performances are included.

For the financial firm performance the Return on Assets (ROA) will be used, also called Return on Investment (ROI). This performance indicates the past performance of the company. ROA give an indication of how profitable a firm is according to its total assets, it show how efficient the assets are used to generate profits. This ratio is measured as annual net income divided by total assets. A higher ROA means that a company is using its assets better to gain profit; they are performing better. The ROA-ratios of the selected companies are available on the ORBIS database.

Another measure of the firm performance is the market-based performance. Market-based performance focus on the future performance of the company. For this performance the Price-to-Book ratio (PB) is used. It compares the stock's market value to its book value. The ratio is calculated as stock price divided by the book value. A ratio higher than 1 indicates that the market is willing to pay more than the settled share price on the balance sheet. A high ratio means that the equity is used efficiently. For this measure the average of high and low values of the ratio are used. This is a better representation of a whole year. The Price-to-Book ratio is extracted from ORBIS.

3.2.3 Control variables

Control variables are added to the model in order to assess the relationship between the independent and dependent variable. Firm size and leverage are the included control variables. These variables might affect the relationship between R&D investment and firm performance.

Firm size is measured as the total assets in thousands of the company (SIZE). Because the total assets can differ in a great way, the natural logarithm is used. By using the log of total assets the values are now normalized, this is essential for the regression analysis. The value of the total assets is available on ORBIS. Another control variable is the leverage (LEV). It controls if the firm performance is influenced by leverage, which is stated by some studies (i.e. Berger & Bonnacorsi di Patti, 2006). Leverage is measured as total debt and liabilities divided by total assets. It measures how much of the assets are obtained from total debt.

3.3 Data

All the data for the variables in the regression analysis are obtained from ORBIS. ORBIS is huge database with company information across the globe, it's provided by Bureau Van Dijk.

3.3.1 Sample

The following search strategy is used in ORBIS. The beginning is with all the active companies in the database. Next step is the location, companies from the Netherlands, Belgium and Luxembourg are selected. Ultimately the publicly listed and formerly listed companies are picked. The selection for companies from the Netherlands, Belgium and Luxembourg is a well deliberate choice. Most of the prior studies with this topic focused on the United States or United Kingdom. So, these countries are chosen from the theoretical relevance. The listed companies are interesting due to the fact that these companies have shareholders, a company who trade their shares on the stock market. The formerly listed companies are also part of the sample. Some companies may go bankrupt but could have been active in the selected years. In order to avoid a selection bias the formerly publicly listed companies are also part of the sample.

The years of observation are 2012 and 2013. These are the most recent years available. The R&D expenditure is increased in these years in comparison with the previous years, this is also stated in the introduction. All publicly and formerly publicly listed companies from the BeNeLux in the years 2012 and 2013 are observed. But unfortunately not all the R&D expenses are available in ORBIS. The companies with no available R&D expenditures are removed. So there are now companies with R&D expenditures and companies with zero expenditure. Prior studies mainly focused on companies with R&D expenditures, thus companies with an RDI above zero. In this research companies with zero R&D expenditure are also part of the sample, in order to sustain a strongly balanced dataset.

The extreme values of the dependent variables, the measurements of the firm performance are removed from the sample. These extreme values could influence the regression. That's why the dependent variables should have a normal distribution. Since, there are two measurements of the firm performance, the outliers from both are removed. When a company is missing a value or having an extreme value it's removed from the sample.

The analysis for ROA and PB is separated, due to the extreme or missing values. Some companies have only a missing or extreme value on one variable and are, therefore still available for the other measurement. The sample consists of companies with 'normal' variables for both years.

3.4 Descriptive statistics

In table 1 the descriptive statistics of the sample are presented, in the upper half for ROA and in the lower half for PB. The sample consists of 195 and 189 companies respectively for the ROA and PB analysis.

The ROA varies between -11,73% and 18,90%, with a mean of 3,13%. The price-to-book ratio have a minimum of 0,07 and a maximum of 3,20 with a mean of 1,23. The amount of the net sales spent in R&D, the R&D Intensity, have in both analyzes a maximum of 28,07% and minimum of 0%. In this case 0% means that the companies aren't spending on R&D. The companies with higher than 100% were removed, because these companies invest more in R&D than the amount they obtained from sales. The companies with a LEV percentage higher than 100 are also not part of this sample and removed. It means that these companies have more debt than assets, and are financial weak. This could be a sign the company is near bankrupt, because bad operating companies influence the results they are removed.

Table 1; Descriptive Statistics

	N	MIN	MAX	MEAN	ST. DEV
ROA (%)	390	-11,73	18,90	3,13	5,26
RDI (%)	390	0,00	28,07	1,37	3,94
LEV (%)	390	0,09	99,72	54,29	18,31
SIZE	390	8,43	18,45	13,46	1,93
PB	378	0,07	3,20	1,23	0,66
RDI (%)	378	0,00	28,07	1,15	3,51
LEV (%)	378	0,09	94,03	53,63	17,88
SIZE	378	8,85	18,45	13,31	1,90

For the second hypothesis the type of industry is added. The distinction between manufacturing and non-manufacturing companies is made. Influences of industry type are tested with the two analyzes of firm performance.

The sample has a total of 195 companies for the ROA-analysis. 79 Companies are manufacturers and 115 non-manufacturers[2]. The PB-analysis has 78 manufacturing companies and 111 non-manufacturing companies. Table 2 presents a clear overview of the type of industry distribution.

There is an interesting difference. The sample also consists of companies with zero R&D expenditure and that are mainly the non-manufacturing companies. Vice versa the companies with R&D expenses are mainly manufacturing companies. With this information a little conclusion could be made. R&D is more important for manufacturing companies than for non-manufacturing companies.

[2] For one company the US SIC code is missing, so this company is removed.

Table 2; Distribution manufacturing companies and non-manufacturing companies.

	ROA	PB
Manufacturing companies	79	78
Non-manufacturing companies	115	111
Total	194	189

4. RESULTS

This section provides the results, the empirical evidence for the effects of R&D on firm performance and the differences for manufacturing and non-manufacturing companies.

4.1 R&D investment and firm performance

4.1.1 R&D investment on ROA

With the Pearson Correlation Coefficients correlations between the variables are shown. In table 3 the correlation matrix for the ROA-analysis of the firm performance is presented. Significant results are marked with asterisk, one for 90% significance, two for 95% significance and three for 99% significance.

Some asterisks are shown in table 3, it means that there are significant correlations. The values in the correlation matrix will provide a little indication of the relationship. But when the independent variables are highly correlated with each other a problem can arise. This problem is a statistical phenomenon and is called multicollinearity. When there is a presence of multicollinearity in the variables, the results are not reliable. Because the predictor variables are already predicted by the other independent variables. The correlation between RDI and RDI^2 is a high one and significant, but because it's the squared term of the other it's not a problem. For possible multicollinearity between RDI, LEV and SIZE the VIF-values (Variance Inflation Factor) are analyzed. This factor measures how much the variance of the regression coefficient is increased by collinearity. VIF-values greater than 10 indicate a multicollinearity problem (Kutner et al, 1996)). But the VIF-values in my analysis are far under the 10, so there's no multicollinearity between my independent variables.

The RDI have an insignificant correlation of 0,079 with ROA. The positive correlation means that the larger the RDI is the higher the ROA is. This (little) positive correlations indicates a positive relationship, despite its not significant. The positive correlation coefficients, the positive relationship, correspond to my first hypothesis. In order to confirm my first hypothesis the regression results are also important. The results of my regression analysis are shown in table 4.

Table 3; Correlation matrix

	ROA	RDI	RDI^2	LEV	SIZE
ROA	1				
RDI	,079	1			
RDI^2	,038	,925***	1		
LEV	-,305***	-,114**	-,126**	1	
SIZE	,019	,140***	,122**	,231***	1

* Significant at 90%, **; Significant at 95%, ***; Significant at 99%

In the table of the regression results the regression coefficients are presented. In parentheses the t-statistics are given. The asterisks mark the significant results, just like in the correlation matrix. The observations and the adjusted R^2 are also reported.

First the independent variables RDI and RDI^2 are inserted and ROA as dependent variable. Later the two control variables LEV and SIZE are attached. Without control variables RDI have a significant positive parameter with ROA and RDI^2 a

significant negative. The negative coefficient of RDI² indicates a bend: R&D investment is not linearly related to firm performance. The coefficient of 0,413 means that an increase of 1 percent RDI, the ROA increases with 0,413%.

After controlling for LEV and SIZE the coefficients are still significant positive and significant negative for respectively RDI and RDI². The control variables have a significant negative and positive coefficient. An increase in LEV with 1% will decrease the ROA with 0,09%. The whole model is significant at 99% significance. The regression results stems from 390 observations. The R-squared determines how much of the variances in firm performance are explained by the independent variables. Thus, the ROA is for 11% explained by RDI, SQ_RDI, LEV and size.

At this point my first hypothesis is confirmed by these significant coefficients of RDI and RDI². ''Investment in Research & Development will affect positively the firm performance, in a non-linear way'', with ROA as dependent variable of the firm performance, the financial firm performance.

Table 4; Regression results

	Firm performance			
	ROA	ROA	PB	PB
RDI	0,413**	0,398**	0,042*	0,038
	(2,327)	(2,355)	(1,805)	(1,651)
RDI²	-1,661*	-1,943**	-0,131	-0,126
	(-1,870)	(-2,297)	(-1,133)	(-1,104)
LEV	-	-0,094***	-	0,003
		(-6,565)		(1,314)
SIZE	-	0,242*	-	0,048**
		(1,774)		(2,599)
ADJ. R²	0,010*	0,105***	-0,007	0,029***
N	390	390	378	378

* Significant at 90%, **; Significant at 95%, ***; Significant at 99%

4.1.2 R&D investment on PB

In table 5 are the Pearson Correlation coefficients for the PB-analysis presented. The significant correlations are marked. Just like the correlation for the ROA, here are also some significant correlations between the independent variables. The VIF-value is for this analysis far under the 10, so multicollinearity problems are not applicable.

RDI is significant correlated with PB. The positive coefficient of 0,096 is an indication of the positive relationship. The higher the RDI, the higher the PB. To confirm this positive relationship the regression results are analyzed.

Table 5; Correlation matrix

	PB	RDI	RDI²	LEV	SIZE
PB	1				
RDI	,096*	1			
RDI²	,063	,911***	1		
LEV	,096*	-,039	-,053	1	
SIZE	,162***	,141**	,131**	,210***	1

* Significant at 90%, **; Significant at 95%, ***; Significant at 99%

For the market-based firm performance, PB, the regression results are also shown in table 4. Before the control variables are added the coefficient of RDI and RDI are in the same direction as for the ROA. But only the parameter of the RDI is significant, namely at 90%. The parameter of 0,042 is interpreted in the same way, so an increase of 1% RDI is an increase of 0,042 PB.

When the control variables are added the direction of the relationship is still the same. However, it is now insignificant. The variable SIZE is 95% significant with a coefficient of 0,048. The directions of the parameter indicate the relationship stated in the first hypothesis. But with no significance this hypothesis is rejected for the market-based performance.

4.2 Manufacturing companies versus non-manufacturing companies

In the previous subsection significant results and evidence is found to assume that R&D investment positively affects the firm performance for the ROA-ratio. In this subsection results are presented to check if there are differences for the type of industry.

4.2.1 ROA-ratio and industry types

First the descriptive statistics are shown in table 6. The manufacturing companies have a higher mean on RDI than the non-manufacturing companies. Also the maximum is higher by the manufacturing companies.

Table 6; Descriptive statistics

Manufacturing companies					
	N	MIN	MAX	MEAN	ST. DEV
ROA (%)	158	-11,73	17,38	3,54	5,21
RDI (%)	158	0,00	28,07	3,00	5,54
LEV (%)	158	4,57	94,03	54,28	15,86
SIZE	158	9,39	18,45	13,53	2,03
Non-manufacturing companies					
ROA (%)	230	-11,14	18,90	2,83	5,3
RDI (%)	230	0,00	14,86	0,25	1,49
LEV (%)	230	0,09	99,72	54,18	19,87
SIZE	230	8,43	17,07	13,43	1,84

The correlations given in table 7, presents that RDI is more correlated with ROA by non-manufacturing companies. The manufacturing companies also have a negative insignificant correlation with ROA. The correlations indicate that non-manufacturing companies are more positively affected by R&D investment than vice versa. This is not in line with the second hypothesis. VIF-values far under the 10 are not given any multicollinearity problems in this model.

However, the regression results in table 10 show that the coefficients of RDI before the control variables are higher for manufacturing companies. Respectively, 0,188 for the manufacturing companies against -0,006. But after the control variables are added the coefficient is for non-manufacturing higher, namely 0,461 against 0,202. One percent increase in RDI means that the ROA will increase by 0,202 for manufacturing companies and 0,461 for non-manufacturing companies. These coefficients don't confirm the expectations. With these insignificant coefficients hypothesis 2 is rejected for the ROA-analysis.

Both models are significant at 99%. For the manufacturing companies 22% of variability in the ROA-ratio stems from the included variables. The ROA-ratio for non-manufacturing companies is 14% explained by the variables.

Table 7; Correlation matrix

Manufacturing companies					
	ROA	RDI	RDI²	LEV	SIZE
ROA	1				
RDI	-,005	1			
RDI²	-,035	,929***	1		
LEV	-,472***	-,182**	-,199**	1	
SIZE	-,131	,218**	,175**	,216**	1
Non-manufacturing companies					
	ROA	RDI	RDI²	LEV	SIZE
ROA	1				
RDI	,269***	1			
RDI²	,282***	,955**	1		
LEV	-,223***	-,101***	-,132**	1	
SIZE	,134*	-,009	,020	,258***	1

* Significant at 90%, **; Significant at 95%, ***; Significant at 99%

4.2.2 PB-ratio and industry types

The descriptive statistics presented in table 8 show that the manufacturing companies have a higher mean and maximum for the RDI. Manufacturing companies spend more of their net sales on R&D than non-manufacturing companies on average.

Table 8; Descriptive statistics

Manufacturing companies					
	N	MIN	MAX	MEAN	ST. DEV
PB	156	0,07	3,06	1,28	0,66
RDI (%)	156	0,00	28,07	2,46	5,00
LEV (%)	156	3,27	94,03	54,59	16,18
SIZE	156	9,39	18,45	13,4	2,04
Non-manufacturing companies					
PB	222	0,19	3,20	1,20	0,66
RDI (%)	222	0,00	15,35	0,22	1,20
LEV (%)	222	0,09	92,24	52,95	18,99
SIZE	222	8,85	16,53	13,25	1,80

The correlations in table 9 match with the second hypothesis. The correlation coefficients of manufacturing companies are higher than the non-manufacturing. The indications are consistent with hypothesis 2. Multicollinearity is also not a problem in this analysis. The regression coefficients and t-statistics are presented in table 10.

Table 9; Correlation matrix

Manufacturing companies					
	PB	RDI	RDI²	LEV	SIZE
PB	1				
RDI	,105	1			
RDI²	,069	,916***	1		
LEV	,068	-,119	-,115	1	
SIZE	,203**	,261***	,218***	,194**	1
Non-manufacturing companies					
	PB	RDI	RDI²	LEV	SIZE
PB	1				
RDI	,080	1			
RDI²	,068	,914**	1		
LEV	,110	,045	,012	1	
SIZE	,126*	-,182***	-,170**	,221***	1

* Significant at 90%, **; Significant at 95%, ***; Significant at 99%

Before and after adding the control variables the parameter of RDI are both bigger for non-manufacturing companies. The coefficients aren't significant. For the PB-analysis the second hypothesis is also rejected. But the indication with these findings is that non-manufaring companies are more positively affected than manufacturing companies. Both models for manufacturing companies and non-manufacturing companies aren't significant. The variance explained by the variables are very low, namely 2% for both models.

5. CONCLUSION

The effects of R&D investment on firm performance are studied often in prior studies, but mostly for companies from the United States or the United Kingdom. There is little evidence for relationships between R&D and firm performance in the European countries. The aim of this study was clear, providing empirical evidence for this gap with data from The Netherlands, Belgium and Luxembourg. Return on Assets and the Price-to-Book ratio are used to measure the firm performance. Distinction between the types of industry is applied to check for differences in impact of R&D investment.

The first part of this study tested the impact of R&D investment on firm performance, with a financial performance and a market-based performance. The regression results show a non-linear relationship between R&D investment and the firm financial performance. An inverted U-shape is the result of the regression. R&D investment has a positive effect on ROA till a certain point, then it will decrease. Significant findings for the market-based performance are not found. However, the results gives an indication of the non-linear relationship for R&D on PB. Other studies with a market-based performance found also a curvilinear relationship (i. e. Ehie & Olibe, 2010), but their results are significant. Further research is needed to give better and significant insights for the effects of R&D investment on

Table 10; Regression results

	Manufacturing companies				Non-manufacturing companies			
	ROA	ROA	PB	PB	ROA	ROA	PB	PB
RDI	0,188	0,202	0,034	0,026	-0,006	0,461	0,061	0,064
	(0,927)	(1,119)	(1,302)	(0,983)	(-0,008)	(0,619)	(0,667)	(2,698)
RDI²	-0,976	-1,460*	-0,104	-0,090	7,345	3,172	-0,141	-0,073
	(-1,021)	(-1,733)	(-0,848)	(-0,734)	(1,327)	(0,584)	(-0,203)	(-0,106)
LEV	-	-0,163***	-	0,002	-	-0,065***	-	0,003
		(-6,075)		(0,498)		(-3,778)		(1,107)
SIZE	-	-0,035	-	0,057**	-	0,564***	-	0,047*
		(0,181)		(2,069)		(3,057)		(1,828)
ADJ. R²	-0,006	0,222***	0,003	0,024	0,071***	0,135***	-0,002	0,015
N	158	158	156	156	230	230	222	222

* Significant at 90%, **; Significant at 95%, ***; Significant at 99%

market-based performance.

The effects of the type of industry on the R&D impact are analyzed in the second part. The second hypothesis stated that investment in R&D affect more positively the firm performance of manufacturing companies than the non-manufacturing companies. The descriptive statics shows that the R&D intensity is higher for manufacturing companies. Thus, would this say R&D is more important for manufacturing companies? The regression results aren't providing significant findings. But the insignificant coefficients are still not consistent with hypothesis two. After adding the control variables the impact of R&D investment on firm performance is for non-manufacturing companies bigger. These findings are for the financial performance and market-based performance.

Practical advice stems from the ROA-analysis, with the significant evidence. The optimal point for RDI is 12%, companies could take this in their mind when investing in R&D. Other practical advice cannot derive from this research.

Recurring to the research question, R&D investment has a positive effect on ROA. At a certain point the ROA will decrease, this is because of the non-linear relationship. For further effects of R&D investment on market-based firm performance no significant evidence is found. Just like the differences in impact for type of industry. Extensive and further research could provide findings for these effects.

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