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Intangible Asset Intensity & Stock Performance: A Study on the Effects of R&D Expenditure on Stock Volatility & Returns in the S&P 500

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ABSTRACT

Empirical research has previously linked intangible asset intensity in firms to stock performance. While evidence from the US markets suggest a positive relationship between intangible asset intensity and stock volatility & returns, the findings of this paper suggest otherwise. In this research, S&P500 constituents between the years 1990-2023 have been analysed using R&D expenditure as a measure for intangible asset intensity in companies, filling a gap in literature by studying a broader set of companies from various industries. Contrary to prior findings, this research has revealed a negative relationship between R&D intensity and stock volatility on a company specific level. This finding is attributed to the implied success of R&D projects with increasing levels of expenditure in consecutive periods, which in turn leads to a more stable stock price. Further, although statistically insignificant, the impact of R&D intensity on short term stock returns were discovered to be negative. This finding pronounces the potential negative impact R&D investments create on the short-run due to various accounting phenomena.

Keywords: Intangible Assets, R&D Expenditure, Stock Volatility, Stock Returns

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CHAPTER 1 Introduction

With the advancement of technology, the intangible asset intensity in firms have been steadily increasing over the years. According to Eisfeldt et al. (2020), intangible assets are absent from traditional asset pricing models, despite their growing importance. Company valuations and earnings estimates are therefore unable to incorporate the intangible value that firms carry, losing their ability to make accurate analysis. Due to this increasing uncertainty in valuation techniques, the effects of intangible value may cause disruptions in the market value of firms. Research and development (R&D) is an important aspect to consider when it comes to intangible assets. R&D plays a key role in the creation of these types of assets such as intellectual property and knowledge capital. It is very important to understand how the R&D expenditure plays a role in this case since there are firms with a spending on R&D larger than their earnings Chan et al. (2001). Before its IPO in 2019, transportation giant Uber operated at a loss, continually reinvesting its capital into research and development, fostering intangible asset growth. Despite appearing unattractive to investors using traditional valuation methods centred on cash flow or tangible assets, Uber ultimately achieved remarkable success. Given the increasingly intangible nature of modern firms, understanding the relationship between intangible asset intensity and market value is therefore crucial for investors and managers alike to grasp this complexity present in the stock market.

The inspiration to this research came from the work of Edmans (2011) on the relationship between intangible assets and stock performance. Edmans underscores the significant impact of employee satisfaction, a key intangible asset, on long-term shareholder value, finding a significant positive correlation between the two variables. More similar to the scope of this research; Chan et al. (2001) found positive correlation between R&D expenditure and stock return volatility for firms in the United States using data from 1975-1995. The authors supported their finding by stating that the cause for volatility may be explained by the lack of information around the nature of outcomes of firms' R&D activity. More recently Alsinglawi & Aladwan (2018) investigated the Amman stock market in Jordan and found no correlation between R&D expenditures as an intangible asset measure on the stock volatility. Another similar research by Owiredu et al. (2014) focusing on R&D intensity found negative correlation in the Ghana stock market. While the two findings from recent research contradict the work of Chan et al., both samples are from far less developed countries, where R&D and intangible assets are less pronounced in companies compared to those in the US.

In the light of existing literature, there is still room for exploration regarding the effects of intangible asset intensity of firms on their share price. While research from Edmans puts the emphasis on employee satisfaction, this thesis aims to focus solely on R&D expenditures as a measure for intangible asset intensity. The research by Chan et al. (2001) lays a great foundation for this thesis as it explores a wide array of different effects of the R&D intensity on the market value of public companies including stock performance, which will be the focus of this research. While Chan et al. puts forward a significant positive correlation between R&D expenditure and stock return volatility, its relevance may be limited due to its age, particularly given the heightened prominence of R&D in today's business landscape compared

to the period between 1975-1995. While more recent studies have explored similar effects, particularly in emerging market economies, this research aims to fill a gap by focusing on firms listed in the S&P 500 index. This choice is motivated by the index's representation of companies operating within a highly developed financial market, providing insights into the dynamics of firms in the United States, a leading global economy with significant R&D investment and innovation activity. It is also possible to capture a diverse set of companies varying in R&D levels through the S&P500 unlike previous research where the sample is focused on specific industries such as the firms listed on the NASDAQ. A focus on the tech industry would not be a desirable sample for this research since most tech companies today have significant exposure in R&D making the expenditure gap less pronounced within the sample. The research question for this research is therefore: How does R&D expenditure effect the stock volatility and return for firms in the S&P500?

The sample for this research consists of firms listed in the S&P500, representing large-cap companies in the United States. Annual panel data is utilized to analyse the relationship between R&D expenditure and stock volatility and returns. Further, panel regression techniques such as fixed effects and random effects modelling are used to account for heterogeneity across companies within the sample. By using panel data, the longitudinal variation in R&D expenditure and stock volatility is captured over time. R&D expenditure is used as a measure for intangible asset intensity and given as a percentage of every company's total revenue. The monthly stock returns are compounded to yield an annual figure for stock returns. Volatility on the other hand is captured through the standard deviation measure of monthly stock returns and then annualized. The data is analysed with a focus on short-run impacts of R&D expenditure data that is made available to the public to understand whether investors incorporate such information into their portfolios. The dataset captures the years 1990-2023 and is obtained from the CRSP financial database.

I expect to find that the firms with higher R&D expenditures face higher stock return and return volatility respectively. Although similar literature reached various conclusions, based on the motivation that it is more challenging to value companies with higher intangible asset intensity, the presence of a positive correlation is expected between R&D expenditure and volatility of stock returns. The panel regression that will be employed through this research will show the outcome of the relationship between the two variables. By understanding how R&D expenditures impact stock returns and volatility, investors may gain insights on the risk-return trade-off for intangible asset dominated companies, managers may optimize their spending on R&D and economists may gain a better understanding on the problems with firm valuation techniques in the modern world. Although important to understand, the outcome for this research will still leave room for debate since R&D is not the only aspect of intangible assets and there are many more factors that affect stock performance, beyond what the analysis in this research can control for.

The remainder of this paper is structured as follows. Section 2 will discuss relevant literature and previous research. Section 3 will discuss the data used for this research followed by the methodology that will be employed while utilizing the data. The findings will be discussed in section 4 and conclusions will be made in the final section 5.

CHAPTER 2 Theoretical Framework

2.1 Intangible Assets

An intangible asset is a non-physical asset that carries value. Patents, software, brand value and trademarks are some of the most common intangible assets. Although they carry a value, it is often a challenge to accurately value intangibles due to their non-physical nature. In the International Accounting Standard (IAS) 38 intangible assets are defined as "An identifiable non-monetary asset without physical substance. An asset is a resource that is controlled by the enterprise as a result of past events and from which future economic benefits are expected Criekingen et al. (2021)."

Lev (2001) proposes the following classification groups of intangible assets: (1.) Innovation and learning-related, such as R&D; (2.) Customer-related, such as brands and trademarks; (3.) Intellectual-related, such as industry knowledge and education; (4.) Organization-related, such as logo design, and corporate culture.

A good way to understand intangible assets is to compare them with physical assets. Intangibles work similar to how equipment and machinery does for a company. What separates intangibles is as stated by its name, a lack of physical form. Crouzet et al. (2022) draws parallels on three main points. According to Crouzet, both asset classes are an accumulated factor, they depreciate, and they hold limited excludability. Like any physical asset, intangible assets require an initial capital investment to be created. Intangibles such as R&D are also very important for a company's competitive advantage. When successful, R&D investments can significantly contribute to a firms value and increase its opportunity to grow over time.

Intangible assets also depreciate. Unlike physical wear & tear, the main cause for depreciation is obsolescence. This is especially crucial for R&D. Over time, the knowledge and technology developed through R&D efforts may quickly outdate due to advancements by other firms in the same industry.

Intangibles have limited excludability. In the context of R&D, this means that the knowledge, ideas, or innovations generated through research and development efforts can improve other firms in the industry without reducing their value to the original creator. While intellectual property such as patents or copyrights provide protection, firms often fail to completely exclude third parties from accessing the knowledge they generated through R&D. For instance, competitors in the smart phone industry constantly develop similar products by designing around existing patents that a single firm initially came up with.

2.1.1 Background on Intangible Assets

One of the first ever studies on intangible assets is the work of Sanders & Clark (1924). With their study, Sanders & Clark discuss how certain intangibles may sometimes be part of a firm's value. Their work focuses on intangibles such as goodwill, human capital, and R&D to study their effects on firm value. Goodwill being one of the first intangible items to make its appearance on balance sheets, intangible assets started gaining recognition in accountancy standards in the years that followed Canning (1929).

With the significant jump in technological advancements, and the introduction of the digital age, R&D gained further recognition in financial reporting and intangible assets expanded to incorporate intellectual property and copyrights that firms own Kaplan & Norton (1992). The rise of tech giants such as Microsoft, Google or IBM also displayed the importance of intangible value as the success of such companies can be attributed heavily on their investments in intangible assets. In the modern day, while the covid pandemic continued to elevate the technology aspect of intangibles, the Environmental, Social and Governance (ESG) impact of companies also started gaining recognition as an important intangible asset Eccles et al. (2010).

2.1.2 Valuing and Accounting of Intangible Assets

Accounting plays perhaps the most crucial role in company valuations as it provides the key principles to understand the returns generated from a company while providing insights on how a company makes use of their money. According to regulation issued by accounting standards, most intangible assets are expensed on the income statement without making any appearance on the balance sheet, failing to provide a true overview of company's intangible assets Cañibano et al. (2000). According to Damodaran (2009) accountants do not accurately keep track of one of the first principles of accounting which suggest that expenses that create a benefit over many years are capital expenses and expenses that benefit only the current year are operating expenses. The author states that R&D, the most significant capital expenditure spent by technology and pharmaceutical firms are often treated as operating expenses, as the timing of the benefits are hard to keep track of. According to Chan et al. (2001) due to this accounting phenomena some ratios widely used by investors such as the PE ratio or the market to book value are also falsely reported, pricing firms with high R&D expenditures relative to their total value (R&D intensity) at unjustifiably high multiples making them appear expensive. Other metrics such as return on equity and return on capital also lose integrity as these ratios would constantly fluctuate depending on whether R&D expenditure gets recorded as an operating or capital expense by the firm, which could advocate higher levels of volatility for the stock of the company over a longer period.

It is also important to note from Damodaran's work that analysts are pushed to rely more on intuition while coming up with a growth rate to make valuations. This is because the conventional accounting methods are not sufficient in meaningfully generating a growth rate for companies with high intangible asset intensity, let alone the uncertainty around whether R&D projects will be successful.

2.2 Previous Studies on R&D Expenditure and Stock Returns

In existing literature, there are quite many research on stock performance predictability and the stock market implications of company specific aspects. The most relevant for this research are literature that investigate intangible assets, similar to what this paper aims to accomplish.

Study by Edmans (2011) found that employee satisfaction was positively linked to long-run stock returns, supporting the idea that the market does not value intangibles accurately. Focusing a portfolio on the "100 Best Companies to Work for in America", Edmans found the presence of an annual four-factor alpha of 3.5% from 1984 to 2009. While supporting the same hypothesis as Edmans (2011), Daniel and

Titman (2006) further argued that while tangible information reflects past performance, intangibles predict the future. According to their research on how the market reacts to intangibles, while tangible information failed in predicting future returns, the future returns were linked to unexplained performance in the past, showing the importance that intangible assets carry. Tan et al (2007), who examined the ‘’Value Added Intellectual Coefficient’’ a measure for intellectual ownership also found positive correlation between intellectual capital intensity and stock returns, showing that certain forms of intangibles may be accounted for by the market.

The finding that R&D intensity positively impacts future returns is consistent among various research. Apergis and Sorros (2014) found positive correlation between R&D expenditure and profits linked to energy use for the fossil fuel and renewable energy sectors in the US for the sample period between 1990-2011. Chambers et al. (2002) further conclude that the presence of R&D expenditure cause mispricing by investors leading to future positive returns for firms traded in the NYSE, NASDAQ and ASE during the years 1979-1998. Another study covering the lengthy period between 1951-2001 by Eberhart et al. (2004) reached the same conclusion that R&D expenditure leads to positive abnormal returns with a sample of over 8000 US firms. There are similar findings on the impact of R&D expenditure on earnings. Study by Healy et al (2002), who used a simulation model for a pharmaceutical R&D program and Yuan et al (2011) who researched firms in the S&P 500 between the years 1996-2005 observed positive correlation between the two variables for firms in the United States.

2.3 Previous Studies on R&D Expenditure and Stock Volatility

The importance in understanding intangible assets is becoming more crucial each day. While intangible assets were always part of companies, the effect of their intensity continues to grow Chan et al. (2001). This movement can be explained by the R&D component of intangible assets. Chan et al. investigated the R&D intensity of firms on their stock performance for the periods 1970-1999 and found positive correlation between R&D intensity and stock volatility. With its focus on American companies, the study faced a limitation due to the regulatory state during the sample period. For some years in the sample period, firms in the US were not widely reporting their expenses on R&D. Therefore, the authors used various metrics as proxy to generate an accurate estimate of R&D expenditure of US firms. This limitation is no longer, and it is possible to reach R&D data for a great number of companies. Regardless of its availability, it remains unclear in what ways and to what extent investors incorporate this information.

On the contrary, there are two studies conducted on stock markets outside the US which find negative or no significant effect of R&D on stock performance. Research by Alsinglawi & Aladwan (2018) investigated the stock volatility with respect to R&D expenditure for companies listed in the Amman Stock Exchange. For the sample period of 1990-2018, the research found no significant relation between R&D expenditure and stock volatility for companies in Jordan. Another study by Owiredu et al. (2014) found negative correlation between R&D expenditure and stock volatility in the Ghana stock market between years 2001-2011. While showing results that contradict with what was previously portrayed by researchers,

both papers focus their investigation on a far less developed stock market than the US therefore leaving more room for investigation.

2.4 Research Expectations

R&D is considered an intangible asset because it represents investments made by a company to develop new knowledge that initially lacks physical presence but can generate benefits. While fostering innovation, R&D allows companies to achieve long term growth, generate value and most importantly contribute to the creation of intangible assets. R&D innovation can lead to newly established patents, trademarks, and copyrights, further making R&D a good measure for intangible asset intensity Damodaran (2009).

While R&D on its own is perceived as a beneficial investment, there is often uncertainty on whether the investment will truly benefit the firm in the future. It could therefore be the case that investors often disregard the positive impact that R&D may create in the future. Yet, this is uncertain. There are many investors alike that invest based on promises that pharma companies make, that they are very close to curing cancer with their R&D practices or growth investors who invest in technology companies, hoping to see them shift the paradigm with their R&D.

R&D spending is also highly associated with the creation of patents. Prodan (2005) found a positive correlation between R&D spending and number of new patents created by a company in OECD Countries and Central Europe during 1981-2001.

Further, Hagedoorn & Duysters (2002) studied the computer industry in the US during the 90s and found a significant positive correlation between R&D intensity and innovation. A similar study by Cardinal & Hatfield (2000) this time on the pharmaceutical industry in the US found the same relationship, highlighting R&D's impact on contributing to innovation. The presence of this correlation further underscores using R&D to measure intangible asset intensity in companies.
In light of these findings, the hypotheses for this research are as follows:

R&D and Stock Volatility

H_1: *R&D Expenditure has a positive effect on stock volatility*

R&D and Stock Returns

H_2: *R&D Expenditure has a positive effect on stock returns*

CHAPTER 3 Data & Methodology

3.1 Sample

Due to its diverse range of large cap companies with various levels of spending on R&D, this research is focused on companies that have been listed on the S&P 500 between the years 1990 and 2023. The year 1990 was chosen because the availability of data on R&D expenditure for the sample is much higher compared to the years prior. The setting of the research imposes a challenge on obtaining the data required for the research since the companies on the S&P 500 continually changed over the thirty-three-year time frame. To reach data for all the companies that were once part of the S&P 500, the list of all S&P500 constituents was extracted from the WRDS database. The output obtained was then used in the query to reach data on company stock and fundamentals for those specific S&P 500 constituents in WRDS. While data on fundamentals such as R&D expenditure is available on quarterly or annual bases, it is possible to reach stock data on a monthly frequency. All the data required for this research was obtained from the CRSP/Compustat Merged Database by Wharton Research Data Services (WRDS).

3.2 Dependent & Independent Variables

This paper aims to study the effect of intangible asset intensity on stock volatility and returns. To achieve this, the variables of interest are the R&D expenditure, stock volatility and stock returns. As discussed earlier, R&D expenditure provides a good measure for intangible asset intensity in companies. For that purpose, the R&D spending of each company was extracted as an annual figure for every year in the sample period. The data for stock performance was obtained from the Security/Monthly sub-dataset of the WRDS, which provides data on stock returns on a monthly frequency. To match the frequency of R&D expenditure data, the monthly stock returns were compounded and annualized to represent the annual return for the year. To measure volatility, the standard deviation of monthly stock returns were computed and then annualized for each figure. Doing so created a better ground to merge the two datasets, while allowing for a more comprehensive analysis on stock volatility and returns. The resulting volatility variable was also transformed using logarithms which will be discussed further.

3.3 Control Variables

Further, there are several control variables that must be obtained to achieve unbiased research using R&D expenditure. To ensure this, the stock performance was controlled for by using other company-level data. It is important to control for factors such as firm size, revenue and dividends since all such factors have been associated with stock performance in past research Rahman & Howlader (2022). From the database, the company-level fundamentals data was extracted on an annual basis. It is possible to reach this annual data for over two thousand S&P 500 constituent companies for the given sample period.

Controlling the sample for size is of great importance since the R&D expenditure will heavily depend on how large the company is. To achieve a fair comparison between companies, the amount of R&D expenditure was divided by the total revenue amount of each company. The resulting variable is called R&D intensity, since it provides figures on how much companies invest in R&D with respected to

their scale. The market value of each company was also included in the dataset as it can further control the variables for company size.

Considering previous research, the earnings per share as well as dividends per share were included in the dataset as both are key ratios that have been used by investors for many years to understand the profitability of a company Jawabreh et al. (2022). Additionally, the book value per share was also considered for analysis since it is used by investors as an indicator to spot the so-called undervalued stocks.

The dataset also includes two other metrics that investors often use while investing in companies. These variables are the return on asset and the leverage ratio. The return on assets (ROA) is important as it highlights a company's efficiency in generating profits from its assets. The ROA was calculated by dividing the net income by the total asset amount for each company. The second key ratio is the leverage ratio which investors use to understand the level of debt a company holds with respect to the total company value. This ratio was calculated through dividing the total debt by the sum of debt and market value of each company. The descriptive statistics of the variables mentioned above can be found below on Table 1.

Table 1 Descriptive Statistics

	Mean	Standard Deviation	Min	Max
Stock Return	0.18	0.52	-1	10
Ln (Stock Volatility)	5.49	1.05	-2	14
R&D Intensity	0.06	0.94	0	86
Book Value Per Share	19.33	29.04	-244	897
Dividends Per Share	0.87	1.45	0	52
Earnings Per Share	2.38	6.63	-196	320
Leverage Ratio	0.23	0.20	0	4
Ln (Market Value)	8.94	1.55	-2	15
Return On Assets	0.04	0.12	-6	3
Observations	27109			

Correlation matrixes are useful in understanding and spotting relationships between R&D intensity as well as other control variables with the stock volatility and returns. The first correlation matrix on Table 2 representing the stock volatility shows that R&D intensity is positively correlated with stock volatility, indicating that higher levels of R&D spending is associated with higher stock volatility. The second correlation matrix found on Table 3 shows the relationship between the dependent variable stock return with R&D intensity and other control variables. The matrix puts forward an interesting result. Based on the negative coefficient, R&D intensity is associated with lower stock returns in the short run. While these findings serve as a guide to understand the link between variables, the variables should be examined further in a regression to understand their true relationship.

Table 2 Correlation Matrix Stock Volatility

	Ln (Vol)	R&D	Ln (MkV.)	BPS	DPS	EPS	Leverage Ratio	ROA
Ln (Vol)	1.00							
R&D	0.05	1.00						
Ln (MkV.)	-0.15	-0.02	1.00					
BPS	-0.26	-0.01	0.27	1.00				
DPS	-0.19	-0.03	0.56	0.21	1.00			
EPS	-0.00	0.01	-0.15	0.12	-0.04	1.00		
Leverage Ratio	-0.37	-0.04	0.19	0.28	0.24	-0.03	1.00	
ROA	-0.21	-0.10	0.02	0.06	0.31	-0.11	0.23	1.00

Notes: LN(Vol): Natural Logarithm of Annualized Stock Volatility, R&D: R&D Intensity, Ln(MkV.): Natural Logarithm of Market Value, BPS: Book Value Per Share, DPS: Dividends Per Share, EPS: Earnings Per Share, ROA: Return on Assets

Table 3 Correlation Matrix Stock Returns

	Stock Return	R&D	Ln (MkV.)	BPS	DPS	EPS	Leverage Ratio	ROA
Stock Return	1.00							
R&D	0.01	1.00						
Ln (MkV.)	0.03	-0.04	1.00					
BPS	-0.02	-0.03	0.17	1.00				
DPS	-0.05	-0.04	0.28	0.25	1.00			
EPS	0.05	-0.03	0.22	0.57	0.20	1.00		
Leverage Ratio	-0.03	0.01	-0.04	-0.16	0.13	-0.04	1.00	
ROA	0.09	-0.14	0.20	0.01	0.06	0.31	-0.11	1.00

3.4 Methods

The main relationship of interest in this paper is given by the following equations:

$$Stock\ Volatility = R\&D\ Expenditure \times \beta_1 + \mu_1$$

$$Stock\ Return = R\&D\ Expenditure \times \beta_1 + \mu_1$$

It was noticed further during analysis that the distribution of R&D was skewed to the left. While having such distribution violates the normality assumption, the R&D data was not transformed using logarithms since the R&D data contains '0' values that cannot be mathematically transformed using logarithms, which would lead to companies with no R&D spending being eliminated from the dataset.

Further, based on their distribution, the annualised stock volatility as well as the market value variables were transformed using the natural logarithm. The concern in transforming R&D is not present for these variables, hence they were stored after taking their natural logarithm to satisfy the normality assumption.

While the dataset includes historical S&P500 constituents, some of these companies are not active in the current day and some indeed has went bankrupt. With such companies the stock returns are bound to be negative for certain periods prior to their collapse, which cannot only be attributed to their R&D expenditure. As this would manipulate the regression results for stock returns, data for companies with an inactive status marker were removed prior to the analysis on stock returns.

The dataset contains several time series observations for each given company, meaning that a panel data is being dealt with. For this reason, a cross-sectional time series regression was used. To prepare the data for a panel regression the data was sorted by the Standard & Poors identifier code (specific code for each company) and year. Going further, the analysis was conducted in two parts namely for stock volatility and then for returns.

Before adding control variables, prior analysis is needed to see if a random or fixed effects regression fits the dataset best. To do so, results from both regressions were independently stored and tested using a Hausman test to determine which regression was right for the given data. The Hausman test applies the following hypothesis.

H_A: *Individual effects are correlated with the independent variables*

For both tests the conclusion is to proceed with the analyses using fixed effects since a significant coefficient was obtained and the null hypothesis was rejected.

Going further, a White Test was conducted on the chosen regression method to understand the heteroskedasticity of the standard errors. Robust standard errors were used respectively of the test results.
To enhance the analysis, an industry variable was generated to cluster the companies in certain industrial categories using the SIC (Standard Industrial Classification) code of each company present in the dataset. There are certain SIC code intervals that represent an industry. For instance, companies with an SIC code between 6000 and 6800 are part of the Finance, Insurance and Real Estate industry.
The first part of the analysis is on the stock volatility. Using fixed effects and robust standard errors the effects of R&D expenditure on stock volatility was investigated.

Surely, the analysis requires several control variables (company fundamentals) found on Table 1.

$$Stock\ Volatility = \propto_1 + R\&D\ Intensity \times \beta_1 + \boldsymbol{Company\ Fundamentals} \times \beta_i + \mu_1$$

$$Stock\ Returns = \propto_1 + R\&D\ Intensity \times \beta_1 + \boldsymbol{Company\ Fundamentals} \times \beta_i + \mu_1$$

The relevant control variables for both analyses were determined using a general-to-specific / specific-to-general approach where control variables were added/removed considering their correlation and significance levels. The final regression model based on significance levels for stock volatility and return respectively are given as follows:

$$Ln(Stock\ Volatility) = \propto_1 + R\&D\ Intensity \times \beta_1 + \boldsymbol{Book\ Value\ per\ Share} \times \beta_2 + \boldsymbol{Earnings\ per\ Share} \times \beta_3 + \boldsymbol{Leverage\ Ratio} \times \beta_4 + \boldsymbol{Ln}(\boldsymbol{Market\ Value}) \times \beta_5 + \boldsymbol{Return\ on\ Assets} \times \beta_6 + \mu_1$$

$$Stock\ Return = \propto_1 + R\&D\ Intensity \times \beta_1 + \boldsymbol{Book\ Value\ per\ Share} \times \beta_2 + \boldsymbol{Earnings\ per\ Share} \times \beta_3 + \boldsymbol{Dividends\ per\ Share} \times \beta_4 + \boldsymbol{Ln}(\boldsymbol{Market\ Value}) \times \beta_5 + \boldsymbol{Return\ on\ Assets} \times \beta_6 + \mu_1$$

CHAPTER 4 Results & Discussion

4.1 The effects of R&D Expenditure on Stock Volatility

Table 4 reports results on the stepwise cross-sectional time series regression that was conducted on stock volatility. The regression was completed in three steps. The second column represents the results based only on the relationship between the dependent and independent variable. On the next column, stock market-based company metrics are added to the model, followed by the company fundamentals on the final column. Based on the negative significant coefficient of -0.0156 in the third panel regression (the most meaningful model), on a firm specific level, as R&D intensity increases, the stock volatility decreases. Although earlier R&D intensity displayed a positive correlation with stock volatility on Table 2, the regression accounting for company level fixed effects with several control variables proved otherwise. The positive effect can be observed on the first panel regression model with no control variables, although the coefficient is not statistically significant with an R-squared value of near zero, therefore not providing any meaningful findings. The results become meaningful after the second model and the sign and magnitude of coefficients across all variables remain similar after including the final set of control variables in model 3.

Table 4 Panel Regression on Stock Volatility

	Panel Regression (1)	Panel Regression (2)	Panel Regression (3)
	Ln (Stock Volatility)	Ln (Stock Volatility)	Ln (Stock Volatility)
R&D Intensity	0.0116	-0.0158***	-0.0156***
	(0.0084)	(0.0022)	(0.0021)
Ln (Market Value)		-0.2958***	-0.2964***
		(0.0128)	(0.0136)
Leverage Ratio		0.4613***	0.4965***
		(0.0809)	(0.0812)
Return on Assets		-0.8240***	-0.7092***
		(0.1187)	(0.1135)
Book Value Per Share			0.0014***
			(0.0005)
Earnings Per Share			-0.0063***
			(0.0017)
Constant	5.4871***	8.1044***	8.0838***
	(0.0005)	(0.1145)	(0.1197)
Observations	27109	18945	18945
R2	0.0001	0.1160	0.1175
Adjusted R2	0.0001	0.1158	0.1173

Notes: Standard errors are given in parentheses,
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All control variables in the regression portrayed meaningful results in line with prior expectations. Further, when considering R&D expenditure, there were no differences found between industries regarding volatility in the research as all industry categories were omitted due to multicollinearity. The R-squared of 0.12 (rounded) in the final model indicates the presence of a weak relationship between the independent variables and the dependent variable, hence much of the variance in stock volatility remains unexplained.

With these findings the first hypothesis stating a positive relationship between R&D expenditure and stock volatility is rejected as a significant negative relationship was discovered between the variables.

4.2 The effects of R&D Expenditure on Stock Returns

Table 5 reports results on the stepwise cross-sectional time series regression on stock returns. Three regressions were conducted following the same steps in section 4.1, the final column representing the most meaningful model. Similarly to what can be spotted on the correlation matrix found on Table 3, the fixed effects regression did not provide a positive coefficient. While there is a negative relationship between the dependent and the independent variable across all models, the research proved that there were no significant effects of R&D intensity on stock returns since the p-value of the coefficient was not significant at any level.

Table 5 Panel Regression on Stock Returns

	Panel Regression (1)	Panel Regression (2)	Panel Regression (3)
	Stock Returns	Stock Returns	Stock Returns
R&D Intensity	-0.0137	-0.012	-0.0125
	(0.0099)	(0.0099)	(0.01)
Ln (Market Value)		0.0295***	0.0435***
		(0.0071)	(0.0085)
Return on Assets		0.3868***	0.3112***
		(0.0684)	(0.0665)
Book Value Per Share			-0.0015***
			(0.0004)
Earnings Per Share			0.0033***
			(0.0011)
Dividends Per Share			-0.0164***
			(0.0047)
Constant	0.1842***	-0.1205*	-0.2055***
	(0.0005)	(0.0645)	(0.0732)
Observations	18939	14546	14546
R2	0.0002	0.0127	0.0185
Adjusted R2	0.0001	0.0125	0.0181

Notes: Standard errors are given in parentheses,
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All other control variables portrayed significant results in line with expectations, remaining with the same sign and similar magnitudes across models. The industry categories were once again omitted as the returns between industries were not significantly different from one another, accounting for their R&D intensity. Regardless of the presence of independent control variables, the R-squared of 0.02 indicates a quite weak relationship within the model. This is as although expected as stock returns are affected by many more factors that are not all quantifiable given the research design and are very challenging to explain without a broader market context.

According to these findings there was no evidence found to reach a conclusion on the second hypothesis stating a positive relationship between R&D expenditure and stock returns and the true relationship between the two variables remains uncertain.

4.3 Discussion

Findings from both analyses provided results contrary to what was expected in this research. The results differed from previous research done with a similar setting such as Chan et al. (2001) who found positive relation between intangible asset intensity and stock volatility using R&D, for companies listed in the USA, or Chambers et al. (2002) who associated intangible asset intensity with positive stock returns. The results of this research were rather similar to those of Owiredu et al. (2014) who found a negative significant relationship between R&D intensity and stock volatility for companies listed in the Ghana Stock Exchange.

While the relationship between R&D intensity and stock volatility was initially positive, the panel regression on firm specific characteristics yielded an opposite result. This can be attributed to the fact that heightened amounts of R&D spending in consecutive periods show that the R&D efforts are proving to be useful, leading the company to allocate more resources on such investments. This in a way shows that the uncertainty around whether R&D efforts would be successful decreases with increased spending. The company therefore signals to its investors that the chance of growth opportunities elevate with higher spending on each period. The opposite can also be argued that when R&D spending decreases in consecutive periods, certain projects are abandoned, and the growth opportunities attached to the projects cease to exist. This effect can hence be an appropriate explanation to the positive relationship between R&D intensity and stock volatility on a firm level.

Regarding the negative relationship between the dependent variable stock return and R&D intensity, an argument regarding fundamental analysis could be put forward. While R&D and other intangible assets attached to it are associated with growth in the long run, its short-term impacts on companies' balance sheet may hinder investor sentiment as it very often leads to very large expenses being incurred. It is although not possible to reach a conclusion on the effect of R&D intensity on stock returns for S&P 500 constituents in the sample due to the insignificant findings. According to the findings of this research, stock performance is unlikely to be associated with R&D intensity in companies on the short term.

CHAPTER 5 Conclusion

In this thesis, the effect of intangible asset intensity in S&P 500 constituent companies on their stock volatility and returns have been examined through their level of R&D expenditure. The main research question for this research was: "How does intangible asset intensity affect stock performance?"

To answer this question, data has been extracted from WRDS for the years 1990-2023 for companies that have been listed in the S&P 500. After being sorted, the panel data has been analysed using a fixed effects regression with two separate analyses on stock volatility and returns respectively. Going further, other company-level data was included in the research as control variables that were found to be relevant for this research. The results from the stock volatility analysis showed that there is a negative relationship between increasing R&D intensity and stock volatility on a firm level. Analysis on stock returns further showed that there was no association between R&D intensity in firms and their stock returns in the short run. While previous research in the US has shown results that associate R&D expenditure and a broader range of intangible assets with higher stock volatility, the findings of this paper lead to a different conclusion and it remains unclear whether the R&D investment of firms affect their short run stock returns.

The results of this research may have some implications for investors. While innovation is considered key in certain industries and R&D is important for a company's long-term growth and competitive advantage, intangible asset intensity may not be a point for concern regarding stock volatility. Investors should rather focus on other fundamental metrics such as earnings per share, leverage, or the return on assets, which have shown significant relationships with stock volatility and returns in this research. Although the effects are not immediate, R&D intensity in firms have been linked to stock returns in the long run by prior researchers. Therefore, investors should take a long-term perspective with investments based on R&D intensity instead of seeking short term gains.

For company managers, it should be highlighted that being transparent with R&D expenditure and intangible asset intensity allows for more appropriate valuations and growth prospects which can boost investor sentiment. While accounting of intangible assets has improved over the years, the methods used in reporting remain questionable and can result in inefficiencies in the stock market.

In conclusion, while there is a negative relationship between R&D intensity in firms and their stock volatility, the effect it has on stock returns on a short-term remains unclear. While intangible asset intensity in firms may not be directly linked to short-term returns, their implications on a longer-term horizon should not be taken lightly, as certain intangible assets such as R&D expenditure may be key to sustained growth and stability in companies.

5.1 Study Limitations

A potential limitation for this research is that certain lagged effects of R&D expenditure was not included in the analyses. While this research focused on the short-term implications of intangible asset intensity, especially since R&D on its own is a long-term concept, the R&D intensity of previous years could be added into the discussion. While R&D expenditure can act as a measure for intangible asset intensity, these

types of assets are much vaster than what R&D expenditure can capture alone. Other categories within intangible assets should therefore be analysed with stock performance in order to reach better conclusions.

Another limitation of this research was the ability to include certain control variables that capture a broader picture of market conditions. The low R-squared obtained with this research should be seen as an important indicator for lack of explanatory variables and future researchers should take into account further measures that could explain stock volatility and returns. For instance, the VIX (Volatility Index) could be considered in order to control for market volatility, although this would require a different research design as employing such metric would not be appropriate for use with panel data such as the one in this research. Further research can also investigate other markets such as those in Europe or Asia to see whether there is such relationship in the rest of the world which would allow for better conclusions to be made on the topic.

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