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# The effect of R&D and intellectual property expenditures on market value for IT software companies in the US

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## ABSTRACT

To remain competitive, the ever-changing information technology (IT) sector requires significant Research and Development (R&D) investments and a strong Intellectual Property (IP) portfolio. This study intends to explore the connection between R&D and IP, intangible assets, and market prices of IT software companies. Drawing on a decade of financial data (2013-2022) from IT software companies listed on NASDAQ, the study utilizes panel data analysis to investigate the impacts of R&D investments and IP on the firms' market values. Both fixed and random effects models show significant positive correlations between R&D spending and market value, consistent with earlier studies. The level of R&D intensity taken as a proxy for a company's IP portfolio, did not consistently influence market value, pointing to a complex dynamic that calls for more investigation.



**Keywords:** IT, R&D, IP

**JEL codes:** G120

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# CHAPTER 1 Introduction

The current functioning of the Information technology (IT) sector has been to seek and embrace invention, change, advancement, and utilization of new methodologies. More importantly, firms in this area have shaped our ways of living and working spaces. More importantly, they have validated their position in the industry by incorporating research and development (R&D). This has turned out to be a major factor for IT software companies to set themselves apart from other businesses in an intensely competitive market. The IT software industry has been at the front of spending on R&D for the last 10 years as shown in Appendix A. Therefore, many companies that started focusing on tangible assets began questioning whether they should use up those valuable stores of resources while neglecting some of these prized intangible assets such as patents, copyrights, and trademarks. Therefore, IT software companies intensified their investments regarding R&D and intellectual property (IP) so that they establish themselves ahead of the competition, setting up an intriguing research topic for researchers as well as stimulating insight into what goes behind the scenes of the IT industry. Griliches (1981, 1987) were some of the first to suggest a positive link between R&D and market values. Additionally, Tseng and James Goo (2005) found that intellectual capital is associated with increased corporate value. Such findings highlight the significance of intangible assets for companies' success and long-term growth.

Previous papers have examined the relationship between intangibles and market values. Edmans (2011) examined the relationship between equity prices and employee satisfaction, and whether the stock market fully values intangibles. This paper used data from a variety of sources, namely economic data sets, financial information on companies and stock market indicators. The results suggest that the R&D investment has little impact on releasing new products to market because there is evidence indicating that the firms with high employee satisfaction are mispriced, contrary to other firms' perceptions regarding the significance of research and development investments in capturing future growth opportunities. However, Chauvin and Hirschey (1993) investigated the relationship between advertising, R&D expenditures and market value using financial data on advertising and R&D expenditure including market value data as well over 15 years. They found that there are significant and consistent impacts made on the market value of a firm by both advertising and R&D expenditures, showing that their combined effects make a greater contribution than either could individually. Furthermore, Griliches (1987) looked at the role played by R&D patenting and patented technologies within different industries when valuing firms, by using a sample of publicly traded firms from different industries and analysing the relationships between R&D and patents investments stock prices implementation suggested that stock markets do consider how effective patents performed in a given industry when assessing the value of past R&D and IP  efforts plus its current R&D activities. However, due to rapid developments in telecommunications and IT domains, the company might have to invest heavily in projects which end up not yielding the desired profits and therefore diminishing returns. Consequently, this makes it more important for IT software companies to concern themselves on what projects they should give higher emphasis on R&D through knowing what kind of effect these intangibles possess to be able to manage them appropriately. Hence, it is required enormous rounds of investment in R&D aiming at staying competitive enough in the IT industry so an adequate amount of further research on this topic is crucial.

While several studies have investigated the relationship between intangible assets and market values, still a few issues related to this relationship remain unclear. For example, while most research has shown that there is a positive link between R&D investments and market values, still it remains uncertain whether the market fully incorporates the value of intangible assets. This happens particularly in the rapidly changing IT industry as such industries are highly dependent on R&D and innovation for intangible resources such as patents, copyrights, and trademarks.

The IT industry also allows one to consider how rapidly technological expertise changes with rapid innovations in hardware-software systems. A result of this interdisciplinary nature is an industry characterized by having to constantly innovate to stay ahead of competitors with increased pressure being put on firms to heavily invest in R&D owing to technologically progressive advancements and competition within the field, as previously mentioned. Thus, due to the strong empirical argument exhibited above among other reasons, this would label IT as a scholarly ideal industry for looking into seeking information about the relationship between intangible assets and market values.

The ability to additionally address some of these issues will further enhance the scope of exploration involved in offering new perspectives into understanding the relationship between intangible assets and market values especially when trying to understand what drives the market values of IT software companies. Specifically, the study will seek to look at how R&D investments relate to IP impacting the market values of IT software companies. It should be noted that addressing these issues will offer new perspectives in knowledge discovery on the relationship between intangible assets and market values in the IT industry thereby shedding light on the factors that drive the market values of IT software companies.

The study will use panel data analysis to investigate the relationship between intangible assets and the market values of research objectives. The unit for the study in this paper is the IT software companies listed on the NASDAQ stock exchange, with emphasis on companies based in the United States. For accounting and patents information, this research leverages data gathered from the Bloomberg terminal database and the USPTO Patent database. The data will be extracted from the years 2013 to 2022. The study will control for other recorded factors that may affect the market value of the companies among them company size, profitability, and industry characteristics.

My expectations are that an examination of R&D investments, IP, and the market values of IT software companies will indeed yield a positive relationship between these variables. The study will contribute to the literature on this topic by examining how the market fully incorporates intangible assets into determining the market values of IT software companies. Secondarily, the study will contribute to our understanding of the factors driving the market values of IT software companies. In terms of scope and measurement, the research has been narrowed down to focus exclusively on the consideration of the relationship between intangible assets and market values of IT Software Companies listed on the Bloomberg database. This may limit the generalisability of the relationship across other types of IT companies or companies in different industries. Even so, this research project will aim to provide a particularly thorough analysis of that relationship.

Results wise, this thesis finds that R&D spending significantly boosts the market value of IT software companies. A 1% rise in R&D spending leads to a 0.06-0.074% increase in market price. However, R&D intensity does not significantly impact on the market value.

The study also identifies that volatility can boost a firm’s market value, whereas the impact of total intangible assets varies across models. R&D expenditure relationship to returns remains significant even when controlling for firm-specific characteristics and broad time trends. Interestingly, the study also finds that ROE and ROA impact on profitability may vary when comparing across industries rather than within a same industry. The findings highlight the complex dynamics between R&D investment, firm-specific characteristics, industry context as well as market value.

# CHAPTER 2 Theoretical Framework

## 2.1 The Relationship between R&D Expenditures and Market Value

This paper will look at R&D investments and Intellectual Property (IP) as the primary predictors in this study. These investments are what sets these companies apart, especially in the IT industry, a fiercely competitive industry in that sense. In this regard, the importance of R&D expenditure has been looked upon in different ways, through different relationships and through different roles. Firstly, the relationship between R&D expenditure and market value has been supported by studies as already mentioned by Griliches (1981). Using a market valuation approach, Hirschey (1982) investigates the intangible capital aspects of advertising and research and development (R&D) expenditures. The study finds that, on average, R&D expenditures positively and significantly affect a firm's market value. These expenditures significantly affect a firm's market value, suggesting their accounting treatment as intangible assets to be amortised over their useful lives. Eberhart et al. (2004) follow this idea through a paper that examines a sample of 8,313 examples from 1951 to 2001 where firms suddenly boosted their R&D spending by significant amounts. According to the study, businesses that unpredictably boosted their R&D spending displayed an unusual operating performance in the five years following the increase. The market was found to be slow to fully recognise the benefits of R&D growth as a result. It was also observed that with an increase in R&D costs, high-tech companies do better than low-tech companies.

Johnson (1967) and Sougiannis (1994) established that the effect of an increase in R&D expenses on profit is $2 over seven years as well as $5 in market value. It is possible to distinguish between both a direct effect and an indirect effect regarding new R&D information being directly communicated by R&D variables. Through this, R&D investment influences market values through earnings. However, the indirect effect seems to be much bigger than the direct effect for these reasons.

Contrary to what has been stated above, Chan et al. (2001) examined the stock market values of technology-focused companies' intangible R&D capital. It argues that since the stock price should reflect the value of a company's R&D capital in an efficient market, there should be no correlation between the level of R&D and future stock returns. According to the paper, the market may take longer to adjust its expectation toward companies who invest extensively in

R&D while having a bad performance record. During these cases, the management is generally enthusiastic regarding the prospects of their respective companies.

The same Sougiannis (1994), blamed these findings on the econometric methods used in these papers and later provided a reason for this. These three factors include sample size, cross-sectional correlation, and data quality.

Using a time series method, Callen and Morel (2005) examine the value significance of Research and Development (R&D) expenditures in the context of firm valuation. Depending on the exact valuation model chosen, the authors identify that the relationship between R&D and market prices is significant for a maximum of 25 per cent of their sample in a firm-level time series environment. This implies that R&D spending might not be equally valuable or relevant as once assumed. R&D spending becoming directly valuable or relevant to companies with better book-to-market ratio growth prospects is a topic that has received little research. Additionally, they argue that due to the deeper option value of R&D, the value significance of R&D investments may be higher for riskier companies.
According to FASB Statement No. 2 (1974): "A direct relationship between research and development costs and specific future revenue generally has not been demonstrated". This was due to FASB Statement No. 2 dictating that all R&D expenses have to be recorded as they are incurred. The financial statements and management choices of a corporation may be impacted in several ways by this accounting method. From a short-term point of view, particularly for companies involved in R&D-intensive industries, the R&D expenditure can be expected to weaken reported net income instantaneously. More importantly, should management devote themselves primarily to short-term financial performance, requiring paying these R&D costs, could conclude they will choose to invest less in R&D instead.

Given these impacts, it has been suggested reformulating accounting standards to allow R&D costs to be capitalised and spread out across the lifetime of those assets produced by R&D operations could be worth it. A more realistic picture of the long-term profitability and value of the asset might also result in a stimulated increase in R&D costs.

Shevlin (1991) investigated how off-balance sheet financing and R&D Limited Partnerships (LPs) affected how capital market investors evaluated the equity market values of R&D companies. The study uses an option pricing framework to interpret the LPs, allowing for estimates of both the asset and liability components of the R&D LPs. In particular, the article shows that when determining the market value of R&D companies, investors consider the call option feature of R&D LPs to be important information. This indicates that investors believe R&D spending and the market value of the companies are correlated. Furthermore, the significant coefficient on the in-house R&D variable in their market value regressions suggests that investors capitalise on R&D expenditures, even though firms expense them as required under FASB Statement No. 2 (1974). This indicates that investors see a positive relationship between R&D expenditure and market value, as they expect these expenditures to generate future benefits for the firm. The study also points out that alternative hypotheses regarding variables that R&D firms frequently overlook can have a significant impact on the estimations of the LP variables and the regression coefficients. This shows that the specific assumptions and information accessible to investors may have an impact on how the relationship between R&D expenditure and market value is perceived.

Moreover, Hirschey and Weygandt (1985) aimed to determine whether these expenditures positively affect a firm's market value, which would suggest their accounting treatment as intangible assets to be amortised over their useful lives. The results suggest that advertising and R&D expenditures systematically influence a firm's market value over time. This suggests that these costs qualify as types of intangible capital investments. According to the research and based on the effect that these costs have on market value, the study provides reasonable estimates that R&D has a "life" of five to ten years, but advertising has a "life" of one to five years.

Likewise, research by Griffith, Huergo, Mairesse, and Peters (2006) highlighted the significance of R&D spending in encouraging innovation and productivity. They were able to distinguish between the efficiency of creative work in generating productivity improvements and the contribution of R&D intensity by using a structural model that links R&D spending, innovation output, and productivity. As a result, this research made the decision to examine IP development in more detail.

### 2.2 The Role of Intellectual Property in R&D and Market Value

Intellectual property refers to those intangible assets owned by a business or individual that are protected from unauthorised use. In the IT industry, this often takes the form of patents, copyrights, and trademarks. This allows companies to try and gain an edge over each other and protect it. However, there is a high uncertainty and risk reflected in the R&D expenses, as reflected in the FASB statement 2. This could potentially undermine the importance of protecting these future benefits through the use of IP. However, companies would be wrong to follow this path as Manap et al. (2016) found a correlation between crucial secret information leaks and lower R&D spending, which is exacerbated in areas with weak intellectual property rights safeguards. R&D initiatives are directly impacted by the legal protection of these activities and the enforcement of property rights, which in turn have a substantial impact on economic and industrial growth.

Hence, this suggests that a company with IT rights over its R&D can gain a competitive edge over secrecy. Dass et al. (2015) examined whether differences in the specific advantages of patenting over secrecy affected companies' stock liquidity and their capacity to obtain capital from investors. Results pointed to a reduction in information asymmetry and financing differences due to the significant growth of patenting over secrecy. Meaning, the harmed firms were able to increase their investment activities.

This was previously backed by Kultti, K., Takalo, T., & Toikka, J. (2007) who argued an incentive to invest in R&D is the existence of a patent system, which offers some level of protection for inventors. This is so that inventors may ensure a return on their R&D efforts by preventing unauthorized usage of their discoveries through the patent system.

Anton, J. J., & Yao, D. A. (2004) argue that small inventions won't be replicated, according to the model, unlike medium and big process breakthroughs, which may result in legal action or possible licensing. By comparing the shift in market share between both instances, it is possible to determine the innovation's significance. Larger improvements that result in considerable cost differences will provide the innovator a larger market share.

The model also predicts that very significant cost differentials won't be associated with stealing in sectors where property rights are typically upheld, while some low-royalty licensing may take place. A company may strive to obtain large licenses, supported by the fear of patent enforcement, and raise fee revenue by exposing more information because of the strength of property rights, which in turn encourages the competitors to come up with additional ones.

## 2.3 Hypothesis

H1: There is a positive relationship between R&D expenditures and the market values of IT software companies.

H2: A positive relationship exists between the strength of a company's IP portfolio and its market value.

The empirical study of the connection between R&D spending, IP, and market valuations in the IT industry will be guided by these hypotheses. The results will contribute to our knowledge of the variables that influence the market valuations of IT software companies and the purpose that intangible assets play in this process. It will focus on how R&D investments and IP contribute to the market value of IT software companies, offering insightful information to both academics and industry professionals. In conclusion, this study's theoretical foundation is predicated on the knowledge that R&D expenditures and intellectual property (IP) have a considerable impact on the market valuations of IT software companies. This knowledge is derived from prior studies and the distinctive features of the IT sector. The study seeks to add to the body of knowledge and methodologies used in the IT sector by offering fresh perspectives on this relationship.

# CHAPTER 3 Data

## 3.1 Sample data

This research leverages data gathered from the Bloomberg terminal and the United States Patent and Trademark Office (USPTO) databases. The data was extracted from the years 2013 to 2022 and pertains to companies in the IT software sector in the United States. We are going to be using balance panel data which may indicate that we are falling into a sample selection bias due to only selecting firms that have information during those 10 years and therefore suggesting that these firms could be more stable than the others as they have not gone bankrupt, has not been bought by other companies or have just simply existed during those whole 10 years as examples. However, a balance panel data was selected because even considering the issues we have just mentioned by using panel data we avoid several issues that the imbalanced panel data bring to our analysis. Firstly, the variations in the time period that make the estimation process complicated. Secondly, comparing changes over time can be difficult if different entities have data for different time periods. Thirdly, this may lead to less efficient and inconsistent estimates if the reason for the unbalance is not random. For instance, suppose data is more likely to be missing for smaller firms or certain years, that could bias the results. Therefore, the initial dataset comprised data from 750 companies listed on Bloomberg over 10 years. This large sample size was chosen with the understanding that a significant amount of data might be missing or insufficient for the purposes of this study. In fact, half of those companies do not possess R&D data. Following an initial review and filtering of the data for completeness and relevance to the study, the final sample included data from 75 companies. This process can be found in the following table where every variable was dropped individually to show the number of missing values for each one of them individually. Undoubtedly, some firms will be missing more than 1 variable and hence the addition of all the missing variables won’t add up to the final number of firms left with all the variables.

Table 1. Number of dropped observations per variable.

| Variables | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|
| Returns | 308 | 292 | 278 | 255 | 238 | 217 | 188 | 164 | 117 | 23 |
| R&D expense | 461 | 435 | 414 | 419 | 431 | 371 | 280 | 253 | 260 | 264 |
| R&D intensity | 428 | 416 | 399 | 387 | 363 | 303 | 245 | 223 | 205 | 201 |
| Revenues | 391 | 376 | 357 | 346 | 322 | 262 | 197 | 170 | 154 | 154 |
| Book value per share | 395 | 381 | 356 | 346 | 327 | 287 | 216 | 173 | 149 | 145 |
| Volatility | 323 | 308 | 283 | 271 | 240 | 202 | 178 | 123 | 26 | 71 |
| Total intangible assets | 434 | 406 | 383 | 373 | 353 | 293 | 222 | 184 | 177 | 174 |
| ROE | 555 | 548 | 536 | 529 | 525 | 500 | 474 | 423 | 378 | 392 |
| ROA | 429 | 418 | 399 | 394 | 370 | 331 | 297 | 221 | 182 | 186 |
| PRICE | 292 | 278 | 255 | 238 | 217 | 188 | 164 | 117 | 23 | 11 |
| Final number of firms | 162 | 178 | 191 | 188 | 176 | 198 | 234 | 273 | 321 | 301 |

Considering the missing observations that we have just shown and having in mind this strategy aligns with the approach of Eberhart (2004), who began with a set of 35406 firm-to-year observations and ended with a final sample of 8313 firm-to-year observations, this count aligns with the initial expectation of obtaining a sample size within the range of 70 to 200 firms.

The chosen timeframe allows for the examination of the impacts of R&D on stock prices over the past 10 years. The data used in this study are recorded annually, and in line with Fama and French (1992), who assumed that the fiscal year aligns with the calendar year for all firms for simplicity terms.

The variables used in this study include R&D Expenditure, measured in millions of dollars, R&D intensity, expressed as a ratio, Revenue, measured in millions of dollars, Book Value Per Share, Total Intangible Assets, measured in millions of dollars, ROE (Return on Equity), expressed as a percentage, ROA (Return on Assets), expressed as a percentage, Volatility, measured as a percentage over 360 days, Price per share, measured in dollars and Returns, measured as a percentage.

### 3.2 Variables

*R&D Expenditure*

This is the total amount of money, expressed in millions of dollars, that a company spends on projects related to research and development over the course of a fiscal year. A company's potential for profitability and growth can be strongly impacted by the amount of R&D spending. Hence, it is an important indicator of how much the company engages in innovation.

*R&D Intensity*

This is a ratio that represents the proportion of a firm's revenues spent on research and development activities. This ratio is a helpful measure of a company's strategic commitment to R&D. High R&D-intensive companies may be expected to have more powerful future earnings growth, which may affect market valuation.

*Revenue*

The total amount of money a company earns from its business activities before expenses are deducted, expressed in millions of dollars. Revenue is a crucial variable as the primary indicator of a company's size and market presence. Because companies with larger revenue frequently have bigger market capitalizations, it could have a direct impact on market value.

*Book Value Per Share*

This is a per-share measure of a company's net asset value, calculated as total common equity divided by the number of shares outstanding.

*Total Intangible Assets*

These are non-physical assets that contribute to a company's potential future value or earnings power, expressed in millions of dollars These include goodwill, patents, copyrights, trademarks, trade names, organisation costs, capitalised development costs and software, franchises, licenses, property right, core deposits intangibles (banks), and intangible portions of prepaid pensions. The variable allows for an assessment of how much of the firm's value is tied to these assets.

*ROE (Return on Equity)*

The ratio is expressed as a percentage and measures a company's net income divided by its average total common equity. This efficiency measure can indicate a company's ability to generate returns from its equity. Companies with higher ROE might be viewed more favourably by the market, impacting their market value.

*ROA (Return on Assets)*

This ratio is expressed as a percentage and measures a company’s net income divided by its average total assets. This is another measure of a firm's efficiency, and it can influence how the market values the firm. Higher ROA might signal more efficient use of assets, potentially leading to higher market value.

*Volatility*

This is a statistical measure of the risk of price moves for a given security, measured as a percentage over 360 days. Higher volatility might be associated with lower market value due to the increased risk.

*Price per Share*

This is the market price for one share of a company's stock, measured in dollars. It serves as a key dependent variable in the model, as the study aims to understand what factors influence this price.

*Returns*

This is a measure of the gain or loss made from investing in companies' stock expressed as a percentage of the original price of the stock. It encompasses both, where applicable, changes in share price and dividends received which are assumed to be reinvested.

Higher returns on price may represent favourable market sentiment and sometimes directly influence the company’s market value. The change in returns on price can also reveal trends over time, contributing to an understanding of how a firm’s strategic decisions such as R&D expenditure impact investor returns.

### 3.3 Descriptive Statistics

Table 2 provides the descriptive statistics of the dataset.

Table 2. Statistics Summary.

| Variables | Mean | Standard deviation | Minimum | Maximum |
|---|---|---|---|---|
| R&D Expense | 591000000 | 2080000000 | 12000 | 24500000000 |
| R&D intensity | 0.167 | 0.125 | 0 | 1.166 |
| Revenue | 4540000000 | 17100000000 | 338863 | 198000000000 |
| Book value per share | 25.604 | 113.160 | -31.881 | 1552.657 |
| Volatility | 0.967 | 3.844 | 0.110 | 5.021 |
| Total intangible assets | 3280000000 | 9790000000 | 10000 | 78800000000 |
| ROE | -0.095 | 0.68 | -6.804 | 2.076 |
| ROA | -0.029 | 0.237 | -1.947 | 0.766 |
| Price | 73 | 114 | 0 | 1375 |
| Returns | 0.363 | 4.122 | -0.995 | 99 |

The variable R&D Expense exhibits a quite large standard deviation compared to its mean. This shows there is great variation in this R&D expenditure across the observations. There are also some noticeable outliers which will be adjusted by using a natural logarithm when using the variable in the regression. Additionally, the Revenue variable has a high discrepancy between the mean and highest value. Since there are companies with extraordinary performance and astonishing conditions the maximum value is much higher than the means. Also, the variable Volatility exhibits a significantly high standard deviation, indicating seriously high variations of this measure between the observations. In other words, inferring possibly higher risks or heightened volatility of their market performance, meaning several companies could face far greater variations in their valuations or returns than other people do. Both ROE and ROA exhibit negative means, which points out, on average, the companies in question have negative returns on equity and assets. This implies that overall, industry profitability as viewed by the firms will meet relatively low or negative levels of profitability. The variable Book Value Per Share exhibits a rather positive mean, while also exhibiting large enough standard deviations. The Returns variable shows an average of 0.363 suggesting a profitable overall investment in these companies. The sizable standard deviation of 4.122 reveals a wide disparity in returns and hence varying degrees of return variances. This is made evident from extreme range from -0.995 to 99 that highlights this diversity amongst some companies that offer exceptionally high returns whilst others may have resulted in losses.

# CHAPTER 4 Method

### 4.1 Panel data and Fixed effects vs Random effect models

The research uses panel data, which offers several key advantages in the context of this study. Panel data consists of observations collected from the same companies over multiple time periods. This type of data enables a richer and more nuanced analysis in comparison to cross-sectional or time-series data.

Panel data allows for the control of each individual firm in the dataset’s unique characteristics that could influence its market value, such as management style or corporate culture. Panel data allows for the explicit modelling of this, which is invaluable in isolating the impacts of R&D and intellectual property expenditures on market value. In addition, panel data is more informative, offering more variability, less collinearity among variables, and more degrees of freedom, enhancing the econometric analysis's efficiency.

In panel data analysis, both fixed effects and random effects models are used to account for the individual characteristics of the variables being studied, which in this case are IT software companies.

The fixed effects model assumes a correlation between panel-specific effects and explanatory variables, estimates within-panel variations and captures panel-specific characteristics. This will enable us to examine while considering the time-invariant properties, the consequences of annual changes in R&D and intellectual property expenditure on market value.

The random effects model assumes that these unique characteristics are random and uncorrelated to the predictor variables. It also can be applied for a wider scope by allowing both time-variant and time-invariant variables in the analysis.

To determine which model is most appropriate for this data set, the Hausman specification test should be applied. This is because the null hypothesis of the test is that these individual effects are uncorrelated with other regressors in the model. Hence, if we fail to reject the null hypothesis, the random effects model would be the right one to be used.  If the null hypothesis is rejected, it suggests that the individual effects are correlated with the regressors, which means they violated some assumptions of the random effects model and hence the fixed effects model might be preferred.

### 4.2 Model

In this regression analysis, we aim to examine the impact of R&D expenses on US IT software companies' stock returns. The dependent variable will be the returns of stock prices, and the independent variable will be the natural logarithm of the R&D Expenditures.

$$R_{i,t} = b_0 + b_1 lnRDE_{i,t} + b_2 VOL_{i,t} + b_3 IA_{i,t} + b_4 ROE_{i,t} + b_5 ROA_{i,t} + b_6 BVPS_{i,t} + \varepsilon_{i,t}$$

In this regression analysis, we aim to examine the impact of R&D intensity on US IT software companies' stock returns. R&D initiatives are frequently linked to the creation of original concepts, innovations, and intellectual property. R&D-intensive businesses are more likely to create and safeguard intellectual property rights, such as patents and copyrights. Therefore, higher R&D intensity or expenses may indicate a greater likelihood of having valuable IP assets. Therefore, R&D intensity will be used as a proxy for patents in IT and test the second hypothesis. To further support this a natural logarithm of patents and R&D intensity will be generated. After that, running a panel data regression will estimate the elasticity of patents with respect to R&D intensity, controlling for time-invariant firm characteristics. The coefficient on the natural logarithm of R&D intensity in the regression output is the estimated elasticity of patents with respect to R&D intensity. This tells the percentage change in patents associated with a 1% change in R&D intensity.

The panel data regression result, found in Appendix B, suggests that there is statistically significant positive relationship between R&D intensity and the number of patents.

The coefficient on natural logarithm of R&D intensity is 0.4936, which is statistically significant at the 1% level. The above results imply that for every 1% increase in R&D intensity, there appears to be approximately a 0.49% increase in the number of patents when all other variables are held constant.

Such results give a case on behalf of using R&D intensity as a proxy of patents, as they suggest that firms with higher R&D intensity tend to produce more patents.

$$R_{i,t} = b_0 + b_1 lnRDI_{i,t} + b_2 VOL_{i,t} + b_3 IA_{i,t} + b_4 ROE_{i,t} + b_5 ROA_{i,t} + b_6 BVPS_{i,t} + \varepsilon_{i,t}$$

# CHAPTER 5 Results & Discussion

The first approach used in the analysis was the OLS regression. Despite fitting the model well, we suspected fixed and random effects. Hence, switched to a panel data analysis combining a cross-sectional dimension with a time series dimension and created a new variable "ID" to represent each IT software company uniquely. Then, proceeded to set up the panel data structure using the "ID" and "Year" variables. The Hausman specification test was employed to decide between a fixed effects model and a random effects model. After model selection, we examined the residuals of our model. Other than seeing the summary of the residuals for each company, while conducting a panel data analysis, certain diagnostic checks are commonly considered to be essential to guarantee the robustness and validity of the regression results in panel data. For these reasons, the following test, which can be found on Appendix C, are going to be conducted for the two final regression model. Firstly, a heteroskedasticity test to test whether the variance of the errors from a regression is dependent on the values of the independent variables. Secondly, an autocorrelation test, this is due to observations often being correlated due to being collected over time for same people or entities. Thirdly, a cross-sectional dependence test, as in panel data the errors for one individual can possibly be correlated with those of another. Fourthly, a stationarity test, as panel data often involves time series, and a key assumption of many time series models is stationarity. Lastly, a multicollinearity test will be performed as multicollinearity occurs when two or more independent variables in the model are highly correlated. This makes it hard to understand what effect each independent variable has on the dependent variable individually. In panel data models, however, the assumption of independence across observations does not hold anymore due to time and group dependencies. Nevertheless, we are going to be using a workaround by running a regular OLS regression with the same variables as in the panel data model and then compute the Variance Inflation Factor (VIF). This is not the perfect solution, but it can give some insights into multicollinearity situation among the variables. When looking at the residuals there is a considerable variation in the mean and standard deviation of these residuals across different firms in both models. Heteroskedasticity, cross-sectional independence, and autocorrelation was also found to be present in both models. However, the data was found to be stationery and multicollinearity was found to be low. Given this information, it would be appropriate to consider using clustered standard errors in the regression analysis.

The results show that market value for IT software companies is positively and statistically significantly affected by R&D spending. These results were verified with both models of fixed effects as well as the models which include random effects.

Through the analysis of the results, a positive correlation between the natural logarithm of R&D expenditure to the market value was established. As such, increases in R&D during this period would lead to increased market price by 0.06% in case the analysis considers the models of fixed effects and 0.074% cases using the model of random effects. These results might look insignificant but in heavily reliant R&D companies like IT software companies, even these seemingly small percentage increases can translate into a significant increase in market value.

On the other hand, the R&D intensity variable was not found in either of the models to be statistically significant. Hence, relative to total sales, the degree of R&D investment does not have a significant impact on the market value of the firm.

Contrary to initial expectations, a higher book value per share often suggests the better financial health of a company, hence increasing its market value, all models indicated the Book Value Per Share did not show a significant relationship in any model. The Volatility variable was found significant and positive in both fixed effects and random effects models.

This might suggest that higher volatility might increase the market value of the firm.

Similarly, Total Intangible Assets also varied across all the models. It had a significant impact on the fixed effects model with R&D intensity, but not on other models.

Furthermore, inconsistencies were found in the impact of how Return on Equity (ROE) or Return on Assets (ROA) influenced market value across all models. ROE was not significant in any models, whereas ROA only in the fixed effects models. Therefore, these results suggest that these variables may not have the effect initially imputed to them by reducing market value even more than previously assumed.

Moreover, two new fixed effects were added to the regressions to test what would be the results when including year fixed effects jointly with the already considered firm fixed effects. On the other side, every firm was divided into 8 different sub-industries and these firm fixed effects were substituted by industry fixed effects jointly with the newly added year fixed effects. This is shown in Table 4.

After adding firm and year fixed effects to the model, the relationship between R&D expenditure and returns continuous to be statistically significant. This is an interesting finding because it shows that even after controlling for firm-specific characteristics that are unobserved but constant over time and for any time-specific shocks or trends that occur across all firms in a specific year, R&D expenditure still has a statistically significant impact on returns. This implies that this relationship persists even when accounting for the constant, unique characteristics of individual firms and for broad time trends.

When the model shifts, the fact that both R&D expenditure and R&D intensity become statistically significant under control for sub-industry and year fixed effects suggests that these two variables are positively associated within the same sub-industry but also across different time periods as both level of R&D expenditure as well as intensity of R&D investment remain positively associated to returns in both cases.

However, the magnitude of the coefficients is smaller in these models compared to the original regressions, suggesting that there may still be less emphasis on return within the same sub-industry than across the entire industry. The different results derived from the above models point out to the complexity of the relationship between R&D investment and returns and illustrate under what circumstances this relationship can be influenced by level of control for unobserved heterogeneity.

When looking at what happens to the other variables several observations can be made.

In the original fixed-effects models, Book Value Per Share was not found to have a significant relationship with returns. However, after switching to models with firm and year fixed effects and industry and year fixed effects, Book Value Per Share became statistically significant, though the relationship is negative. Hence, this comes to show that within the same firm or industry, an increase in Book Value Per Share is associated with a decrease in returns.

The volatility variable was found significant and positive in all models, hence suggesting that higher volatility might increase the market value of a firm. This finding is somewhat ironic since one might expect higher risk to decrease market value. One potential explanation could be high volatility signals high growth potential in IT software industry therefore attracting investors and increasing market value.

The impact of Total Intangible Assets varied across all models. In the original fixed effects models, it was significant in one model but not in others. In the models with firm and year fixed effects, the impact of Total Intangible Assets on returns was not statistically significant. However, when controlling for industry and year fixed effects, the impact of Total Intangible Assets on returns became negative and significant.

This suggests that within the same industry, an increase in Total Intangible Assets is associated with a decrease in returns. This could be potentially explained by intangible assets being able to sometimes be associated with higher risk and uncertainty which could impact negatively on returns.

The results for ROE and ROA were also inconsistent across models. In the original models, neither ROE nor ROA were significant in any model, whereas in the models with firm and year fixed effects, both became insignificant. However, when controlling for industry and year fixed effects, both ROE and ROA become statistically significant. This could suggest that the impact of these profitability measures on returns might differ when comparing across industries rather than within the same industry.

Table 3. Regression analysis of R&D and Company returns at firm level.

| Estimation dependent variable | Fe (1) Returns | Se (1) Returns | Fe (2) Returns | Se (2) Returns |
|---|---|---|---|---|
| Intercept | 0.399 | -1.472 | -0.703*** | -0.295 |
| | (1.122) | (1.289) | (0.224) | (0.403) |
| lnRDE | 0.060*** | 0.074*** | | |
| | (0.064) | (0.072) | | |
| lnRDI | | | 0.017 | 0.056 |
| | | | (0.097) | (0.146) |
| BVPS | 0.000 | 0.001 | 0.000 | 0.000 |
| | (0.000) | (0.001) | (0.000) | (0.001) |
| VOL | 0.011*** | -0.006*** | 0.011*** | 0.006*** |
| | (0.001) | (0.000) | (0.001) | (0.0003) |
| IA | 0.000** | 0.000 | 0.0000** | 0.000 |
| | (0.000) | (0.000) | (0.0000) | (0.000) |
| ROE | -0.001 | -0.001 | 0.001 | 0.001 |
| | (0.001) | (0.003) | (0.001) | (0.027) |
| ROA | 0.006** | 0.010 | 0.006** | 0.013 |
| | (0.002) | (0.008) | (0.002) | (0.009) |
| Number of observations | 750 | 750 | 750 | 750 |
| R-sq | 0.282 | 0.291 | 0.285 | 0.290 |
| Hausman | | 41.46 | | 41.43 |
| (P-value) | | 0.000 | | 0.000 |

Standard errors in our models were calculated using cluster-robust methods, with clustering performed at the firm level. Statistical significance is indicated by ***, **, and *, which represent significance levels of 1%, 5%, and 10% respectively. The Hausman specification test, which follows a Chi-squared distribution, was applied to determine the preference between fixed and random effects models. Higher Hausman test values lead to the rejection of the null hypothesis, indicating that the fixed effects model provides a better fit for the data than the random effects model.

Table 4. Regression analysis of R&D and Company returns at firm, industry and year level

| Estimation dependent variable | Firm and year fe (1) Returns | Firm and year fe (2) Returns | Industry and year fe (1) Returns | Industry and year fe (2) Returns |
|---|---|---|---|---|
| Intercept | -3.637 | -0.955*** | -1.62*** | -0.269*** |
| | (2.274) | (0.253) | (0.262) | (0.041) |
| lnRDE | 0.166*** | | 0.086*** | |
| | (0.128) | | (0.015) | |
| lnRDI | | 0.112 | | 0.046** |
| | | (0.105) | | (0.018) |
| BVPS | -0.000 | -0.000 | -0.000*** | -0.001*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| VOL | 0.011*** | 0.011*** | 0.006*** | 0.006*** |
| | (0.001) | (0.001) | (0.000) | (0.000) |
| IA | 0.000 | 0.000 | 0.000*** | 0.000 |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| ROE | 0.001 | 0.001 | 0.001** | 0.002* |
| | (0.001) | (0.001) | (0.000) | (0.001) |
| ROA | 0.002 | 0.002 | 0.008*** | 0.011*** |
| | (0.005) | (0.005) | (0.001) | (0.001) |
| Number of observations | 750 | 750 | 750 | 750 |
| R-sq | 0.349 | 0.349 | 0.305 | 0.304 |

Standard errors in our models were calculated using cluster-robust methods, with clustering performed at the firm level. Statistical significance is indicated by ***, **, and *, which represent significance levels of 1%, 5%, and 10% respectively.

# CHAPTER 6 Conclusion

Our first hypothesis stated that there is a positive relationship between R&D expenditures and the market values of IT software companies. The results of the analysis showed a significant positive relationship between R&D expenditure and market value in both the fixed effects and random effects models. These findings align with numerous prior studies including Griliches (1981) and Hirschey (1982), Shevlin (1991), and Hirschey and Weygandt (1985) which have shown a positive and significant relationship between R&D expenditure and a firm's market value. It also mirrors the findings of Eberhart et al. (2004), who found that firms that suddenly boosted their R&D spending saw improved operating performance in subsequent years. Moreover, it further confirms the finding of Johnson (1967) and Sougiannis (1994) regarding the substantial financial impact of R&D spending on profit and market value. These studies, like ours, found a positive and significant relationship between R&D expenditure and market value. However, as pointed out by Callen and Morel (2005), the relationship between R&D and market prices was significant for a maximum of 25 per cent of their sample, suggesting the significance of R&D expenditure can vary widely. In fact, further analyses that control for firm and year fixed effects as well as industry and year fixed effects showed different results. When controlling for firm and year fixed effects, R&D expenditure remained statistically significant, confirming the robustness of the first hypothesis. Contrarily, when switching to industry and year fixed effects, both R&D expenditure and R&D intensity turned out to be significant, though the coefficients were smaller, suggesting that the impact of R&D on returns is smaller within the same industry than across different industries.

On the other hand, our finding contradicts Chan et al. (2001), who argued that there should be no correlation between R&D and future stock returns. This discrepancy may be attributed to the different samples and time periods under study or other economic factors that have changed since the time of their research. It also contradicts Callen and Morel's (2005) suggestion that the relationship between R&D and market value might not be as universally valuable or relevant as once assumed.

Nevertheless, as Callen and Morel (2005) suggested, the relationship between R&D and market value might not be as universally relevant as once assumed, an idea which is partially reflected by the varying significance of our R&D variables across different models.

As Shevlin (1991) suggested, even though firms expense R&D as they are incurred investors still seem to capitalise on R&D expenditures. This aligns with our findings, implying that investors consider R&D spending as an investment expected to yield future benefits, which would in turn increase the market value of the firm.

The second hypothesis proposed that there is a positive relationship between a company's IP portfolio and its market value. Our analysis showed that the variable for R&D intensity, used as a proxy for a firm's IP portfolio, was not statistically significant in either model. This suggests that the intensity of R&D activities does not have a consistent impact on the market value of IT software firms. This finding conflicts with Manap et al. (2016) who found a correlation between leaks of crucial secret information and lower R&D spending, especially in areas with weak intellectual property rights safeguards. Our analysis also showed that the variable Total Intangible Assets, which may also be representative of a firm's IP portfolio, showed inconsistency across models. It was significant in the fixed effects model with R&D intensity and the random effects model with R&D intensity, but not in the models with R&D expenditure. This suggests that while IP might play a role in affecting market value, it may not be as consistently impactful as the R&D expenditure.

However, when introducing industry and year fixed effects both R&D intensity and Total Intangible Assets become statistically significant. This supports the thought that within the same industry, both the intensity of R&D activities and the amount of Intangible Assets held by a firm can affect market value, although the size of the effect might be smaller compared to R&D expenditure.

Our results also match the conclusions of Dass et al. (2015), who found that patenting over secrecy led to a reduction in information asymmetry and improved firms' ability to obtain capital from investors. However, the exact role that IP plays in influencing the market value of a firm may be influenced by numerous factors, including the nature of the industry, the quality of the patents and other IP rights, and the broader market conditions.

In conclusion, our results are that the market value of IT software companies relies more on R&D expenditure than R&D intensity used as a proxy for IP portfolio. However, the complex relationship between IP, R&D intensity, and market value suggests that there is a need for further research in this area to fully understand these dynamics.

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## APPENDIX A IT software R&D

Table 5. R&D expenditure of the top 4 industries in R&D expenditures in the US.

| Industry | 2021 | 2020 | 2019 | 2018 | 2017 | 2016 | 2015 | 2014 | 2013 |
|---|---|---|---|---|---|---|---|---|---|
| Software & Computer Services | 143100 | 109069 | 102790 | 83545 | 68525 | 68.115 | 61.143 | 48.885 | 38.130 |
| Pharmaceuticals & Biotechnology | 111885 | 84064 | 81842 | 74593 | 64918 | 68.058 | 61.233 | 49.221 | 41.437 |
| Technology Hardware & Equipment | 87452 | 75405 | 76616 | 71740 | 64.385 | 65.242 | 63.056 | 57.398 | 48.099 |
| Automobiles & Parts | 22423 | 14851 | 16914 | 16914 | 16.777 | 18.472 | 16.673 | 15.058 | 12.469 |

## APPENDIX B Patents

Table 6. Elasticity of Patents with Respect to R&D Intensity.

| Estimation dependent variable | Fe ln_Patents |
|---|---|
| Intercept | 1.870*** |
| | (0.430) |
| lnRDI | 0.494*** |
| | (0.154) |

## APPENDIX C Diagnostics of errors

Table 7. Modified Wald Test for groupwise heteroskedasticity in fixed effect regression model.

| WT | Fe lnRDE | Fe lnRDI |
|---|---|---|
| Chi2 | 11000000 | 10000000 |
| P-value | 0.000 | 0.000 |

The null hypothesis of this test is that the variance of the error term is constant across all group, hence, it assumes homoskedasticity. If you reject the null hypothesis, this means that there is evidence of heteroskedasticity in the panel data. In this case, both models found heteroskedasticity to be present.

Table 8. Wooldridge test for autocorrelation.

| WOOL | Fe lnRDE | Fe lnRDI |
|---|---|---|
| F-value | 1444.419 | 1446.016 |
| P-value | 0.000 | 0.000 |

In the Wooldridge test for autocorrelation in panel data the null hypothesis is that there is no first-order autocorrelation. Hence, both models were found to have autocorrelation present in their residuals.

Table 9. Breusch-Pagan LM test of independence.

| BPLM | Fe lnRDE | Fe lnRDI |
|---|---|---|
| Chi2 | 3962.226 | 4052.386 |
| P-value | 0.000 | 0.000 |

In the Breusch-Pagan LM test of independence the null hypothesis that residuals across entities are not correlated. Hence, both models were found to have residuals across the different cross-sectional units correlated.

Table 10. The Levin-Lin-Chu test of stationarity.

| LLC | R | lnRDE | lnRDI | BVPS | VOL | IA | ROE | ROA |
|---|---|---|---|---|---|---|---|---|
| T-value | -11.785 | -3.097 | -8.577 | -3.957 | -3.334 | -10.940 | -90.909 | -11.375 |
| P-value | 0.000 | 0.001 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

The null hypothesis of the LLC test is that the series is non-stationary for all cross-sections. This implies that there is strong evidence to claim that the series is stationary for all cross-sections.

Table 11. The Variance Inflation Factor (VIF) of multicollinearity.

| Variable | Fe lnRDE | Fe lnRDI |
|---|---|---|
| lnRDE | 1.89 | |
| lnRDI | | 1.33 |
| BVPS | 1.17 | 1.4 |
| VOL | 1.3 | 1.3 |
| IA | 1.4 | 1.03 |
| ROE | 2.07 | 2.58 |
| ROA | 2.76 | 2.06 |
| Mean VIF | 1.76 | 1.62 |

VIF values range from 1 upwards. If the VIF of a variable is 5 or above, then multicollinearity is high, which can make the estimated regression coefficients unstable and difficult to interpret.

A VIF value of 1 indicates that there is no correlation, and hence, the variance of the estimated regression coefficients is not inflated at all. Therefore, we can conclude that our data is stationary.