Novel insights into stock returns of the US pharmaceutical industry - An exploration of factors predicting success

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Abstract

The pharmaceutical industry comprises companies researching, developing and producing pharmaceutical drugs. The industry differs in many aspects from other sectors due to high reliability on investments in research and development (R&D). Innovation is thus a key feature of the industry and the driving force of success and determinant of growth. However, new trends shape the industry; R&D expenses continue to increase whereas the number of newly approved drugs remains more or less constant. In the light of the changing industry environment and scarcity of previous studies, the aim of this study was to investigate factors that could predict stock return in the pharmaceutical industry, among them R&D expenses and financial parameters. Panel data of 379 pharmaceutical firms in US were analyzed using regressions with both fixed and random effects models. In line with the changing industry environment we found that R&D expenses were in fact negatively correlated with cumulative stock returns for the analyzed companies. Moreover, financial parameters such as advertisement and selling- and general administrative expenses, also negatively correlated with stock return. By contrast, the variable operational leverage displayed a positive correlation. Taken together, these results shed further light on the pharmaceutical industry and provide valuable information for investors.

Keywords: pharmaceutical industry, stock return, research and development, firm characteristics

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1. Introduction

The pharmaceutical industry comprises companies researching, developing and producing pharmaceutical drugs. Characteristics of the global pharmaceutical industry are generally considered to be high profitability and competition but also high volatility in returns. The industry differs from many other industries, due to the considerable amount of time, investment and risk involved for products to proceed from development to market launch and subsequent revenue generation. Moreover, it is mainly dependent on advanced scientific research and development (R&D) activities. Of the world's top 2000 companies listed by their R&D expenses, pharmaceutical firms are indeed at the top together with the biotechnology sector, according to the EU Industrial R&D Investment Scoreboard. The motivations for these R&D activities are partly contribution to firm profitability and competitiveness but also the potential of drugs to relieve suffering and cure sickness (Hwang, 2013).

The potential result of R&D activities is innovation, which is the most important determinant of growth, value creation and future prospects. Research and development is a hallmark of innovative biopharmaceutical companies, and it is closely interconnected to the level of innovativeness in a firm. Innovation thus often emanates through years of highly advanced research, thereby creating a basis for prosperity of a company, even though risks are high. In this context, R&D expenses are often regarded as intangible assets instead of pure costs. This is due to the fact that R&D investments are connected to higher market values of firms as shown in previous studies (Cockburn & Griliches, 1987; Griliches, 1981). They presented data that first confirmed the notion that higher R&D activities are linked to higher company values and thus higher stock prices of companies in general, even though such information about innovation is hard to take into account for regular investors. The significance of innovativeness for long-term revenue in general has also been studied thoroughly in earlier studies (Chan, Lakonishok, & Sougiannis, 1999; Ehie & Olibe, 2010; Roberts, 2001; Shah, Stark, & Akbar, 2008). It has been shown to be the driving force of success and determinant of long-term value. However, there have been limited previous research conducted solely with focus on the pharmaceutical industry. Some studies have studied the relation between market valuation of firms and capital expenditures or product development outcomes, such as drug approvals and patents. Few studies have investigated the pharmaceutical industry exclusively and analyzed multiple variables that could predict future stock returns and compared them to each other.

In addition, the pharmaceutical industry is exposed to new emerging trends that have shaped and continue to shape the industry (Hwang, 2013; Karamehic et al., 2013). Despite extensive research and development expenditures the industry is facing a productivity crisis. The number of newly approved drugs by the Food and Drug Administration (FDA) has remained more or less constant, despite an increase in R&D spending, which in US was doubled between year 1995 and 2002. These facts have raised much concern about the efficiency and organization of conducted research in the pharmaceutical industry, and that research and development costs may not fully capture the whole picture of the prospects of a company. The pharmaceutical industry has experienced a shift in its innovative capacity during the last decade and innovativeness cannot only be measured by direct in-house R&D costs. For example, many firms outsource their research to specialized companies. Furthermore, small innovative companies with new promising drugs in early phase are bought by larger corporations, thus expanding the acquirers' drug portfolio with minimal research expenditures. In the light of these intriguing facts, it would be informative to acquire information about the predictive power of R&D expenses for stock returns and compare it to other variables, including company financials.

This paper sets out to elucidate factors that could affect the stock return in the pharmaceutical industry, and compare them with R&D expenses and their predictive capability to explain stock returns. Panel data of 379 pharmaceutical firms in the United States were analyzed using regressions with both fixed and random effects models. Comparisons were made with data from the bank sector, a control industry with virtually no research and development costs. The three main features that distinguishes this thesis from previous work in the field are i) the market where it is conducted, the authors are not aware of any similar study being conducted on the American market, ii) the comprehensive search for predictive factors for success with critical scrutinization of earlier results and iii) the comparison of factors that could explain stock returns. The obtained results shed new light on the pharmaceutical industry in the US. Plotting R&D expenses over time show that absolute expenses and R&D expenses as a fraction of total assets have increased over time for the analyzed dataset. However, R&D productivity, measured as the number of new molecular entities approved by the FDA, has remained more or less constant. In line with the changing industry environment we found that R&D expenses are in fact negatively correlated with cumulative stock returns for the analyzed pharmaceutical companies for the whole time period 1970-2015. Furthermore, analysis of subperiods revealed a non-significant positive trend between R&D expenses and stock returns during the period 1970-1995, whereas a

negative correlation was obtained for the period 1995-2015, supporting a change in the level of innovativeness. Moreover, financial parameters, such as advertisement and selling- and general administrative expenses, also negatively correlated with stock return. By contrast, the variable operational leverage displayed a positive correlation.

The remainder of this thesis is structured in the following manner. In section 2, a background to the pharmaceutical industry in the United States is presented. Following this, a theoretical and conceptual framework is presented in section 3. It also contains a literature review of important earlier studies. Next, in section 4, a description of the data is provided. This section is divided into five parts, including selection of pharmaceutical companies, retrievement of stock and financial information as well as potential biases. In section 5, there is a description of the methodology used. The results section contains both descriptive results as well as regression results. The implications and discussion section summarizes the results, discusses implications as well as potential further research on the topic. It also contains the conclusions of the study. Finally, the last section contains the appendix where the remainder of graphs, tables and supplementary calculations are to be found.

2. Background

2.1 From idea to revenue - each year counts

There is naturally a large proportion of complexity and uncertainty behind the development of a new drug, balanced by the enormous potential revenues in the future. Drug discovery and the process leading up to a reliable product is in other words very expensive and risky. The drug development process starts by preclinical studies, i.e. laboratory studies, where the potential drug candidate is developed. Thereafter follows clinical studies, through three main phases (I, II and III), where drug safety and effect is established. Finally, approval by the Food and Drug Administration (FDA) is required to market and sell the drug. Prior to approval, no revenues are captured from the drug. In addition, it is noteworthy that every step along the R&D chain may be aborted due to scientific failure, (e.g. lack of drug effect or unacceptable side effects) or solely due to economic reasons (i.e. insufficient revenue expectations). This illustrates that there is a risk of ignorance of scientific advances if there is not an attractive market to target.

The implications of the complex drug development process are many. First, the timescales for preclinical studies are between 1-6 years, for clinical studies (i.e. from Phase I-Phase III) are between 6-11 years and for FDA approval 0.6-2 years (DiMasi, Hansen, & Grabowski, 2003). This implies a total timescale from generating a new idea to first possible revenue of 7.6-19 years. Secondly, the drug to be generating revenues needs an intellectual property (IP) protection in order to secure revenue following FDA approval. The standard patent term in the US is 20 years, with the implication that R&D timescales are essential for pharmaceutical companies, as the revenue gap is delimited to the period after FDA approval and patent expiration.

Clearly, the requirement of FDA approval motivates companies to produce drugs against common diseases with an extensive market share. However, in order to stimulate pharmaceutical companies also to target rare diseases, different types of exclusive marketing rights are given by the FDA, independent of patent expirations. For example, one such right is “orphan drug exclusivity”, which guarantees seven extra years of market protection. To conclude, an important factor that influences the survival of pharmaceutical companies are governmental regulations regarding intellectual protection after drug approval.

2.2 Pharmaceutical industry in North America

The North American research-based pharmaceutical industry is dominated by several multinational corporations, alongside smaller firms such as biotech players focused on a small number of new products. Generics companies are also present. The North American pharmaceuticals market has produced good growth in recent years and is expected to continue to do so into the forecast period in 2019 (Karamehic et al., 2013). The North American pharmaceuticals market contains the mixed economies of Canada, Mexico and USA. USA has the majority of firms in this region. Although the pharmaceutical industry is scientifically challenging, the pharmaceutical market possesses a value of over $300 billion per year in North America (Karamehic et al., 2013). The performance of the market is expected to increase, with an anticipated compounded annual growth rate of 5% for the five-year period 2014 - 2019. The background of growth in the industry is based on the increasing drug revenues and expanded development of novel drugs. One reason for increasing revenues is the increased lifespan, creating a demand of novel and optimized pharmaceutical drugs (Lutz, Sanderson, & Scherbov, 2008). The second aspect, the increasing R&D of new drugs, is based on the progression of new knowledge enabling different new types of pharmaceutical drugs.

2.3 Novel industry trends - external collaborations and R&D methods

In order to remain profitable and competitive, pharmaceutical companies have adapted new strategies to succeed with the R&D process. Half of all scientifically innovative drugs are derived from biotechnological companies or universities (Kneller, 2010). This new trend of collaboration integrates competence from academia in a synergistic profitable fashion and may prove a factor affecting pharmaceutical stock returns in the future. In addition, another trend is the modulation of the R&D process internally, focusing on developing a drug presenting adequate pharmacological effect in humans as early as possible. This is done by early in the preclinical phase validating the effects more extensively. The method, described as “quick win, fast fail”, is considered to lower the number of drug candidates, but ensure their success in the FDA approval process (Paul et al., 2010). If the total development costs are taken into account, including research that does not render any drugs to the market, the cost of developing and successfully launching a new drug has been estimated to be around 1.3 billion USD.

Despite of an increase in R&D expenses during the last decade, the number of approved drugs in US has remained more or less constant according to a number of reports (Cockburn, 2004). In 2010, only 21 drugs were approved by the FDA. In 2009 and 2008, 26 and 24 drugs respectively were approved. Since 2001, the Center for Drug Evaluation and Research has averaged 22.9 approvals a year.

3. Theoretical framework

In this section, a literature review of previously published studies is presented. This literature review presents major previous studies that relate to the hypotheses being tested in this study. First, a general overview of innovation and R&D research in relation to revenue and stock return is presented that is not limited to the pharmaceutical industry. Next, one section devoted to studies on the pharmaceutical industry is presented.

3.1 Innovation and R&D investments

The relation between innovation, R&D investments and the resulting revenue has been studied extensively in the literature for many types of firms. There is no doubt that innovation is strongly interconnected to research and development. It has therefore been suggested that R&D should be viewed as an investment rather than an expense (Pindado, De Queiroz, & De La Torre, 2010). Research and development expenses are thus often regarded as intangible assets instead of pure expenses. This is due to the fact that R&D investments are connected to higher market values of firms as shown by Griliches and Pakes (Griliches, 1981; Pakes, 1985). They presented data that first confirmed the notion that higher R&D activities are linked to higher company values and thus higher stock prices of companies in general. These results have been reproduced in a number of studies which indicate that R&D expenditures correlate positively to the profitability of a firm (Chan et al., 1999; Ehie & Olibe, 2010; Pindado et al., 2010; Roberts, 2001; Shah et al., 2008). However, there have been some studies published that contradict this relationship (Johnson, 1967; Milburn, 1971; Newman, 1968). Sougiannis argues that the results may be due to lack of internal validity, for example small sample size and poor quality of the R&D data (Sougiannis, 1994). Sougiannis and Lev (Lev & Sougiannis, 1996, 1999), found a significant link between research and development expenses and future stock prices. The authors draw the conclusion that the R&D investments are not fully reflected in the stock prices as of today, but are instead associated with future stock returns. Another author that could not find any relation between R&D expenses and stock returns is Bloch (Bloch, 2003). He investigated the effect of R&D expenditures for a range of firms on the Danish stock market using panel data analysis and did not find that R&D intensive firms earn greater returns. Another study found similar results when investigating whether stock prices fully value R&D expenditures (Chan et al., 1999). Moreover, it found that R&D investments are associated with high volatility of stock prices,

displaying the unsecure nature of the innovation process and the risks involved in this process.

3.2 Studies of R&D in the pharmaceutical industry

The correlation between R&D investments and stock return has previously been investigated across different industry sectors. To our knowledge, very few empirical works examine individual stock return at an industry level, even with regard to a research intensive sector like the pharmaceutical sector. The pharmaceutical industry is indeed characterized by the fact that that past innovative efficiency is important for their future stock market return. The mainstay of the pharmaceutical industry, namely R&D, is an important variable presenting the focus on innovation and describing the vector of the company. There are though not many studies that focus on the pharmaceutical industry and very few analyze multiple firm variables. Pérez-Rodríguez and Valcarcel studied the relationship between R&D investment information and stock prices and their volatility. They found that R&D investments increase volatility and leads to an overreaction in price in the pharmaceutical industry (Pérez-Rodríguez & Valcarcel, 2012). Another study found that both volatility and the stock level price are linked to innovation and R&D expenses (Mazzucato & Tancioni, 2012).

3.3 Other key variables

Other variables have been analyzed apart from pure R&D investments and their predictivity of stock prices. Variables reflecting other expenses have been related to firm value. For example, advertisement and marketing have been suggested to have an impact on market value (Shah et al., 2008). Shah et al. argued that advertising may affect the relationship between R&D investment and firm value since, those firms who advertise more allow their products to become more well-known. The view of positive effects of advertising and marketing on market value has been supported by others although exact values have been difficult to obtain due to accounting reasons (Chauvin & Hirschey, 1993). One variable reflecting innovation, namely patents, has been shown to significantly affect market value (Rzakhanov, 2004). Moreover, a recent study has proposed that therapeutic area of a promising drug substance can also be an important determinant of success and future stock returns (Hay, Thomas, Craighead, Economides, & Rosenthal, 2014).

Furthermore, financial data could be a good proxy for stock prices in the pharmaceutical industry as reported by Abbas Kebriaee-zadeh et al. (kebriaeezadeh, Zartab,

Fatemi, & Radmanesh, 2013). They studied the relationship between stock return and key financial data in a pilot study involving 22 pharmaceutical companies in Tehran Stock Exchange over a 7 year period. The results showed that 80 percent of change in stock return can be explained with 9 fundamental variables factors including debt-equity ratio, working capital to total asset, current ratio, net profit margin. Given the limitations of the study (small number of firms and constricted to a small geographical area), this result must be regarded with limited external validity.

3.4 Lack of comprehensive pharmaceutical study

There is consequently a lack of comprehensive studies that investigate the significance of several variables in one paper. There is a need for a paper that elucidates the key determining factors for success of pharmaceutical firms that could also predict future stock return. Moreover, a comparison between R&D investments and other variables is needed. Example of such variables could be market equity (ME) (Banz, 1981), book-to-market equity (BE/ME) (Rosenberg, Reid, & Lanstein, 1985), cash-flow to price (C/P) (Lakonishok, Shleifer, & Vishny, 1994), and past returns (Asness, 1997; Bondt & Thaler, 1985; Jegadeesh & Titman, 1993; Moskowitz & Grinblatt, 1999). These variables are part of what is known as fundamental analysis. It can be hypothesized that these possess significant explanatory power. Interestingly, research often takes place in specialized companies that are part of a corporate group and thus makes research expenses very variable between companies (Kneller, 2010). Moreover, using university collaborations and smaller biotechnology companies as research outsourcing have dramatically changed the way research expenses can be interpreted from the financial reports. In the light of the new emerging strategies in the industry and lack of previous studies, novel knowledge about factors determining stock return is therefore needed.

By further analyzing historical stock returns of major pharmaceutical companies and correlating with several variables and R&D expenses, an attempt to validate and characterize the factors affecting pharmaceutical stock return are made. The new insights from this analysis will provide essential information in the process of selecting and investing in pharmaceutical stocks. As far as the authors are concerned, no similar studies have yet been conducted based on the US market.

3.5 Aims

The aim of this study was to investigate the importance of R&D and other financial variables in the US pharmaceutical industry, with special regard to influence on stock returns. Moreover, another aim was to compare the financial variables with the bank sector as control industry. Our hypotheses were:

1. The changing industry environment has affected R&D productivity in the American pharmaceutical market
2. R&D investments are of decreasing importance in contrast to earlier studies
3. Other key firm characteristics, such as financial information could be predictors of past and future stock return

3.6 Variables of interest

A list of company variables was created based on previous studies that have studied the relationship between key firm characteristics and stock returns (Lam & Wei, 2011). These variables could directly or indirectly be related to stock returns of firms.

Table 1: Company variables of interest. Variables were collected from previous studies that have studied the relation between key firm characteristics and stock returns. Our hypothesis regarding the correlation of these variables to stock prices (positive or negative) are presented for the pharmaceutical industry ("Major Pharmaceuticals") as well as the banking sector ("Major banks"), a control industry (see section 5.2).

Independent variables	**Variable definition**	**"Major Pharmaceuticals"**	**"Major Banks"**
Relative R&D	RD/Total assets	Negative	None
Relative SGA	Selling and general administrative/Total assets	Positive	None
Relative advertising expense (ADV)	Advertising/Total assets	Positive	None
Relative SGA and advertising expense	SGA+ADV/Total assets	Positive	None
Relative intangible assets	Intangible assets/Total assets	Positive	None
Relative property, plant and equipment expenses	Property, plant and equipment/Total assets	Positive	None
Operating leverage	EBIT/Revenue	Positive	None
Debt-to-value ratio	D/V ratio	None	Positive or negative
Relative intangible equity	Intangible equity/Total equity	Positive	None

3.7 Significance

Stocks of pharmaceutical firms are traditionally recognized as aggressive and high return instruments characterized by high volatility. Our paper provides investors and relevant parties an insight regarding the behavior of stock return movement in this sector. In addition, we attempt to give ideas within the framework of investment portfolio diversification as well. It is vitally important to investors to reduce their total portfolio risk and increase total investment return through adequate diversification.

3.8 Limitation of study

This study is based on stock and company financial data downloaded from Wharton Research Data Services repository. It is focused on major listed pharmaceutical companies, which are in the top with regard to research and development spending. One limitation of the study is the time series data consisting of solely "Major Pharmaceuticals". The results are thus only applicable to the sample data analyzed in this study. Nevertheless, the results obtained from the analyses can to some degree be applicable to other, similar in the manner of research-intense, industries, e.g. the biotechnology industry.

4. Data

This section describes the detailed selection of stock data and company financial data used in the investigation.

4.1 Selection of pharmaceutical companies

In order to find the pharmaceutical companies in the US, the stock markets NASDAQ, NYSE and AMEX were screened by "healthcare". The result was 788 companies, separated by the subgroups "Precision Instruments", "Other Pharmaceuticals", "Ophthalmic Goods", "Medical/Nursing Services", "Medical/Dental Instruments", "Medical Specialities", "Medical Electronics", "Major Pharmaceuticals", "Industry Specialties", "Hospital/Nursing Management", "Biotechnology: In Vitro & In Vivo Diagnostic Substances" and "Biotechnology: Electromedical & Electrotherapeutic Apparatus". In order to isolate pharmaceutical companies, 381 companies subgrouped by "Major Pharmaceuticals" were identified and selected. Of these, two companies (RELV and RDY) were excluded due to lack of information regarding size and firm characteristics. Thus, in total 379 companies were included in the following analyses.

4.2 Selection of bank companies

To compare the pharmaceutical industry, stock data for the financial industry was collected from NASDAQ. The result was 639 companies, separated by the subgroups "Accident &Health Insurance", "Banks", "Business Services", "Commercial Banks", "Diversified Financial Services", "Finance Companies", "Finance/Investors Services", "Finance: Consumer Services", "Investment Bankers/Brokers/Service", "Investment Managers", "Life Insurance", "Major Banks", "Property-Casualty Insurers", "Real Estate", "Savings Institutions" and "Specialty Insurers". 286 companies subgrouped by "Major Banks" were chosen for beta calculations, analogously with the selection of "Major Pharmaceuticals" for the pharmaceutical industry.

4.3 Retrievement of stock and financial information

Based on the 379 US "Major Pharmaceutical" and 286 NASDAQ "Major Banks" companies retrieved from the selection described v.s., the stock prices were collected from the WRDS data repository. Monthly data from Jan 1970 to Dec 2015 were chosen for stock prices, in

order to determine a historical beta value for comparison of the industries. Variables retrieved were stock prices, volumes, stock returns and market returns.

From a financial point of view, data regarding the "Major Pharmaceutical" companies were collected for the time period 1970-2015. A special focus on accounting variables, performance variables and industry specific variables were made in the selection of data. This was done in order to acquire the adequate information required to answer the hypotheses.

4.4 Choice of Market Exchange

This investigation studied the NASDAQ, NYSE and AMEX stock exchange (Small, Mid and Large Cap). It is a mature market reflecting the major global pharmaceutical companies, without rendering international diversity as Europe potentially would. To a larger extent than smaller markets, it ensures financial and accounting information availability and accuracy due to legislative requirement.

In order to compare the pharmaceutical and bank stocks in the beta regression, the Standard and Poor's (S&P 500) index was used. This based on the representability of the USA industries, with special regard to the interpretation of the NYSE and NASDAQ exchanges.

4.5 Potential Biases

The calculation of stock returns are regularly based on the closing prices, which by nature may deviate from the true prices. This renders a bias in computed returns,

$$E_{rcomp} = E_{rtrue} + \sigma^2\Delta \qquad (1)$$

where E_{rcomp} is expected return by computation, E_{rtrue} is expected true return and $\sigma^2\Delta$ is the biased error. The level of biased error may be quantified by:

$$\sigma^2\Delta = (P_A - P_B)/(P_A + P_B)^2 \qquad (2)$$

where P_A and P_B are ask and bid prices respectively. The effect of the biased error has been significant in smaller stocks with a low share price, while the error in large-firm stocks with a small bid-ask ratio has been close to zero (Blume & Stambaugh, 1983; Stoll & Whaley,

1983). Considering our selection of “Major Pharmaceuticals”, the impact of biased return errors was to be considered negligible.

5. Methodology

This section outlines the methods and strategies used to derive and validate the results presented in this paper.

5.1 Industry stock beta regression

Regression models are among the most common ways of studying the relationship between two or several variables (Wooldridge, 2012). Apart from being based on our hypothesis, our choice of regression model is based on the structure of our data. Initially, we regress stock returns and S&P 500 returns to determine a beta value according to the capital asset pricing model (CAPM) theory:

$$E(r_i) = r_f + \beta_{im}(E(r_m) - r_f) \qquad (3)$$

where $E(R_i)$ and $E(R_m)$ is expected industry and market return respectively, R_f the risk-free rate and β_i represents the industry beta. The industry beta provides information regarding the non-diversifiable risk of the industry, and is used to illustrate the industry stock characteristics. Beta is a crucial variable in the Capital Asset Pricing Model (CAPM). CAPM creates an estimate for the expected value of a security based on its beta. This required or expected return is equal to the risk-free rate plus a market risk premium, and the market risk premium is the product of a security's beta and the general market risk premium. The beta represents the sensitivity of a firm's stock returns to the overall market risk. A stock with a beta greater than one is more volatile, thus riskier, than the overall equity market. A stock with a beta less than one is less volatile, thus less risky, than the overall equity market.

5.2 Inclusion of control industry

In order to verify that the findings are specifically attributed to the pharmaceutical industry, we perform the same tests in the financial industry, with special regard to "Major Banks". Investments in the banking sector are attributed with less systematic risk compared to investments in the broader market. The sector is composed of many banks that are very large, well-established and have been operating successfully for many decades. Banking stocks tend to offer excellent stability during market downturns; many investors use them as a hedge against exposure to more volatile investments such as biotechnology. Furthermore, the banking industry has no expenses in R&D, thereby making it a suitable control industry.

Thus, findings in the pharmaceutical industry are compared to the banking industry in order to verify the industry-specific effect of analyzed variables.

5.3 Panel data

Previous studies have used a cross-sectional approach to investigate the relationship between research and development and stock returns (Fama & French, 1992) (Lev & Sougiannis, 1996). A cross-sectional regression is conducted by calculating time series averages and by performing t-tests. However, panel data methodology offers many advantages. For example, panel data enables analysis of data under the premises that observations in every cross-section are independent. Consequently, it enables pooling of data (Pakes & Griliches, 1984). Furthermore, the method also facilitates intertemporal dynamics analyses and offers more precise illation of parameters. This study therefore uses panel data estimation exclusively together with fixed and random effects models (see section 5.6) due to the offered advantages. In order to analyze the data in terms of fixed effects and random effects models, the panel data was generated based on two grouping variables, company identification code and date.

5.4 Variables

The company parameters investigated were aimed to reflect financial key points, in order to distinguish “Major Pharmaceuticals” from “Major Banks”, and to correlate stock returns with accounting parameters. The variables selected are RD/Total assets, Selling and general administrative expenses/Total assets, Advertising/Total assets, (SGA+ADV)/Total assets, Intangible assets/Total assets, Property, plant and equipment expenses/Total assets, EBIT/Revenue, Intangible equity/Total assets, D/V ratio and Intangible equity/Total equity.

5.5 Regression analyses

To determine the evolution of RD, assets and returns over time, regression analyses were performed. For this purpose random and fixed effects models were utilized. In order to elucidate the effect of firm financial variables on stock returns, yearly cumulative stock returns were regressed against yearly financial parameters. $p < 0.05$ was considered significant. All statistical analyses were performed using STATA14 (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX: StataCorp LP).

5.6 Random- and fixed-effect models

Random effect models are suitable to observe time invariant variables, and are also called hierarchical linear models. The random effects model makes the assumption that the individual specific effects are uncorrelated with the independent variables. Random effects model has the following equation for regression analyses:

$$y_{it} = \alpha + \beta x_{it} + \gamma_{it} \quad (4)$$

where Y_{it} represents stock return, β a coefficient and vector of parameters to be estimated, X_{it} a financial variable, α the intercept and $Y_{it} = \varepsilon_i + v_{it}$

Fixed effects model can similarly be written as:

$$y_{it} = \alpha + \beta x_{it} + u_{it} \quad (5)$$

where Y_{it} represents stock return, β a coefficient and vector of parameters to be estimated, X_{it} a financial variable, α the intercept and u_{it} an individual specific effect that captures all the variables that affect Y_{it} cross-sectionally. A disadvantage of the fixed effects model is that it cannot observe variables that do not vary over time.

5.7 Hausman specification test

Hausman specification test can be utilized to differentiate between the suitability of either fixed effects or random effects model in the panel data. The null hypothesis states that individual effects are uncorrelated with other regressors (Hausman, 1978). Rejecting the null hypothesis means that fixed effect model is at least consistent with the panel data and thereby preferred (Hausman, 1978). $p < 0.05$ was considered significant.

$$H = (b_1 - b_0)'\big(\operatorname{Var}(b_0) - \operatorname{Var}(b_1)\big)^{\dagger}(b_1 - b_0), \quad (6)$$

where b_1 and b_0 are estimators for b, a vector of regression coefficients and † the Moore-Penrose pseudoinverse. When assuming that the null hypothesis is true, both b_1 and b_0 are consistent but only b_1 is efficient. In contrast, assuming that the null hypothesis is false, b_0 is consistent.

5.8 Multiple testing correction

When performing a large number of statistical tests, some will have significant P-values purely by chance, even if all null hypotheses cannot be rejected. The Bonferroni correction is one way to take this into account. The Bonferroni correction is obtained by dividing the statistical significance level α by number of hypothesis tested (M); Bonferoni correction = α / M.

The Benjamini-Hochberg procedure is a more powerful method to adjust the false discovery rate. Given a list of p-values generated from independent tests, sorted in ascending order, one can use the Benjamini-Hochberg procedure for multiple testing correction. The Benjamini-Hochberg procedure enables a calculation the False Discovery Rate (FDR) for each of the p-values. The calculation will provide information regarding the proportion of the hypothesis that may be considered as false rejections of the null hypothesis. FDR is one way of conceptualizing the rate of type I errors. The false discovery rate (FDR) is calculated by the equation:

$$\mathrm{FDR} = Q_e = \mathrm{E}[Q] = \mathrm{E}\left[\frac{V}{V+S}\right] = \mathrm{E}\left[\frac{V}{R}\right] \qquad (7)$$

where S is the number of true positives and V is the number of false positives (Type I errors), also called false discoveries.

5.9 Robust regressions

Traditional regressions based on ordinary least-squares calculations assume a normally distributed error term, i.e. homoscedastic data, not present in our data set. In order to compensate for heteroscedasticity, robust regression analyses were used (Li, 1985).

5.10 Test of difference between regression coefficients

To determine a possible difference between regressions over time, an F-test were conducted.

$$\mathrm{F} = \frac{\frac{(\mathrm{R}_1 - \mathrm{R}_2)}{(\mathrm{p}_2 - \mathrm{p}_1)}}{\frac{(\mathrm{R}_2)}{(\mathrm{n} - \mathrm{p}_2)}} \qquad (8)$$

where R_1 and R_2 are residual sum of squares for the two regressions, with $p_2 - p_1$ and $n - p_2$ degrees of freedom. In the regressions analyzed by the F-test, homoscedasticity was assumed for simplicity of calculation. $p < 0.05$ was considered significant.

6. Results

In the following section the empirical results of the thesis will be described in detail. The section begins with a financial comparison of the R&D intense pharmaceutical industry with the R&D low bank industry. Results regarding the development of R&D over time in the pharmaceutical industry, with regard to drug approval, are then presented. Moreover, the implications of financial variables on stock return are analyzed for the pharmaceutical and bank industry. The section is finally completed by implementation of robustness tests.

6.1 Descriptive statistics

6.1.1 Comparison between pharmaceutical and bank industry stock returns

By regressing monthly stock returns and S&P 500 index, as described in the methodology section, a beta value of 1.13 was found for ”Major Pharmaceuticals” (see Table 1 and Fig. 1, Appendix). In comparison, the similar beta for “Major Banks” was 0.62 (see Table 2 and Fig. 2, Appendix). Thus, the pharmaceutical industry, as defined, incorporated a larger proportion of risk. By regressing trade volume as a function of returns, it was found that there was a significant dependence between the variables for “Major Pharmaceuticals” (see Table 1 and Fig. 3, Appendix) but not for “Major Banks” (see Table 2 and Fig. 4, Appendix). This implied that volume may predict stock returns for the pharmaceutical industry but probably not for the financial industry. Finally, the yearly volatility of “Major Pharmaceuticals” was determined to be increasing over time (see Table 1 and Fig. 5, Appendix). The current average yearly volatility was 18%. In contrast, the yearly volatility of “Major Banks” was determined to decrease over time and the average volatility was 10.5% (see Table 2 and Fig. 6, Appendix). The findings strengthened that 1) the pharmaceutical industry incorporates a higher risk than the bank industry, 2) the pharmaceutical industry’s higher returns make volatility a variable explaining returns and 3) the pharmaceutical industry has an increasing and higher volatility compared to the decreasing and lower volatility of the bank industry.

6.1.2 R&D expenses and stock returns have increased over time

To determine the development of innovation and research in the “Major Pharmaceutical” companies, total R&D expenses and R&D expenses relative to total assets were regressed over time. Both regressions were positive and significant ($p = 0.001$ and $p < 0.001$ respectively) (see Table 3, Appendix). To investigate pharmaceutical stock performance, stock returns were regressed over time, rendering a positive relation ($p = 0.036$) (see Table 3,

Appendix). The findings strengthen that R&D expenses but also stock returns have positively evolved during the period 1970-2015. Furthermore, to elucidate whether there is a significant difference between total R&D expenses and stock returns over time, an F-test was performed. The result supported a significant difference ($p < 0.001$), implying that the evolution in R&D expenses have not followed the stock returns (see Table 4, Appendix).

Next, we tested whether R&D investments as a fraction of total assets of a company correlated with stock returns of the same company, using cumulative returns for each company. For the whole period 1970-2015 we found that R&D investments are in fact negatively correlated with stock returns ($p = 0.008$ and $p = 0.002$, assuming random and fixed effects respectively, see Table 6 and Table 10, Appendix). However, when analyzing the subperiod 1970-1995, we found that relative R&D expenses showed a non-significant trend for positive correlation with cumulative stock returns. In contrast, analysis of the subperiod 1995-2015 revealed that relative R&D expenses correlated negatively with stock returns using both fixed effects and random effects regressions ($p<0.003$ and $p<0.02$ respectively, see Table 5, Appendix). This strengthens the hypothesis that the changing industry environment has altered the way R&D investments influence stock returns for the companies investigated.

6.1.3 FDA approved drugs per year

The number of approved new molecular entities per year by the FDA has remained stable over the analyzed period in this paper. There was though a slight increase in the number of new drugs approved, however, volatility remains high. As seen in Fig. 1, a peak in the number of approved drugs was observed in 1996 with over 50 drugs approved that year. Normally, the number of approved drugs is around 20 as seen in the graph.

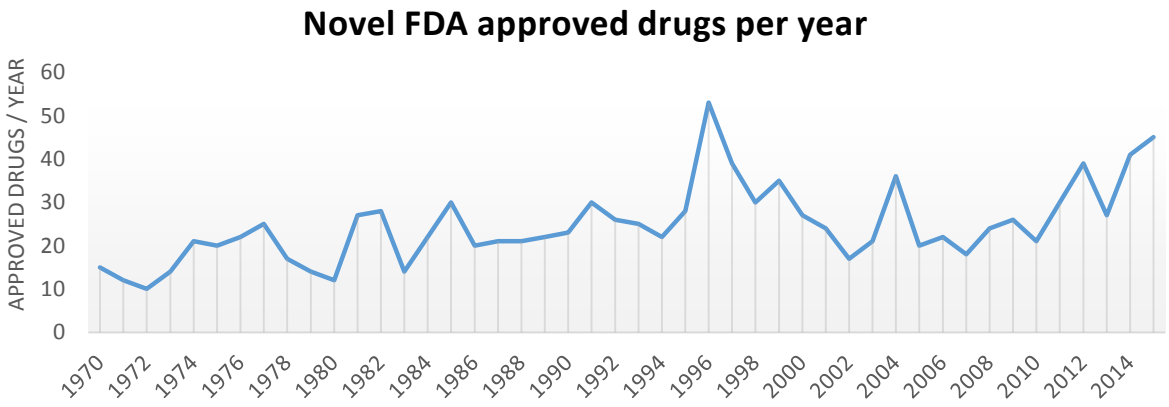

Fig. 1: Number of new molecular entities approved by the Food and Drug Administration (FDA) between the years 1970 and 2015. Data from FDA of approved new molecular entities/drugs were obtained for each of the analyzed years. As seen in the graph, the number of approved drugs during the period is relatively stable over time, with some cyclical variability.

6.2 Investigation of R&D productivity

Although R&D expenses have steadily increased as seen in the data (see Fig. 2), the ratio of new drugs per total investments have fallen since 1995. To test whether the increase in R&D expenses lead to an increased output of new molecular entities (drugs), data from the FDA about number of approved drugs per year was merged with the data. We found that, R&D productivity has indeed decreased in the pharmaceutical industry in the United States, measured as the ratio of new drugs over total R&D expenses. This is in line with our first hypothesis and several reports on the issue from the last decade.

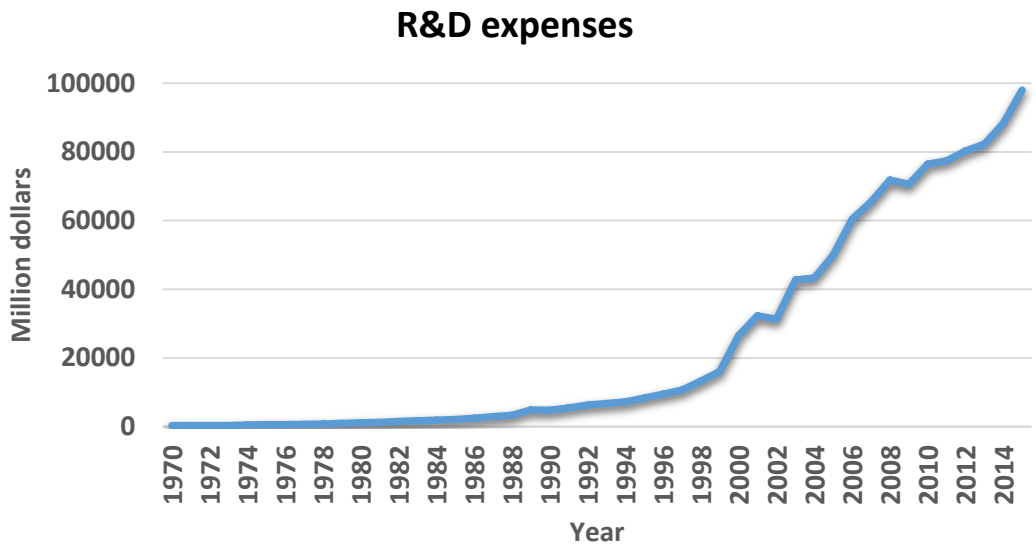

Fig. 2: R&D expenses for the studied 379 pharmaceutical companies between the year 1970 and 2015. Total R&D expenses for 379 firms reveals an increase over time. Some of this effect is attributable to an increase in number of pharmaceutical companies, rather than

6.3 Evaluation of influence of financial parameters on stock returns

The third hypothesis was tested by linear regressions of multiple variables that could serve as a proxy and prediction of stock returns in the pharmaceutical industry. To this end, we chose in total nine key financial parameters, see Table 2. For detailed results see Table 6-11, Appendix. We found that relative selling and general administrative (SGA) costs in the pharmaceutical industry were negatively correlated with stock returns ($p < 0.001$ assuming random and fixed effects respectively), while there was no correlation for the bank industry. Relative advertising was also negatively correlated to stock returns in the studied period of pharmaceutical industry ($p = 0.001$, assuming random effects), while there was no correlation for the bank industry. This effect was however not significant if fixed effect regression was used, as supported by the insignificant Hausman test (see Table 12, Appendix). By contrast,

this variable was not correlated to stock returns in the banking sector. The ratio SGA and advertisement expenses was not shown to have an explanatory power for stock returns, and was not statistically significant for the pharmaceutical or bank industry. Intangible assets are for example corporate intellectual property, patents, trademarks, good etc. These are important indicators of the innovative level of a firm, since they among others, take into account the number of patents a firm has. To test whether the relative intangible assets could serve as a good predictor of stock returns in the pharmaceutical industry, we correlated this variable with stock returns and found that it was not correlated with stock returns for the pharmaceutical or bank industry. To elucidate the role of facilities in the production and indirectly the stock returns, relative property, plant and equipment were analyzed and found insignificant for both industries. Operating leverage reflects how revenue growth affects growth in operating income and suggests the volatility of the operating income. In the major pharmaceuticals industry, the operating leverage was positively correlated with stock returns ($p = 0.002$, assuming random effects). This effect was however not significant if fixed effect regression was used, as supported by the insignificant Hausman test (see Table 12, Appendix). The debt-to-value characterizes the financial leverage and was insignificant in explaining the stock returns of the pharmaceutical and bank industry. Finally, relative intangible equity was assessed, to determine if the equity value of intangibles could provide any significant correlation with stock returns. For the pharmaceutical industry there was no significant correlation, however, for the banking industry, there was a positive correlation.

Table 2: Returns as a function of financial parameters for "Major Pharmaceuticals" and "Major Banks". Company data from year 1970-2015 were analyzed using both fixed and random effects models. The banking sector was used as a control industry. q-values from Benjamini-Hochberg analyses not shown. NA, not assessed. * $p<0.05$.

Returns against financial parameters (p-value)	**"Major Pharmaceuticals"**	**"Major Pharmaceuticals"**	**"Major Banks"**
Independent variables	**Random effects model**	**Fixed effects model**	**Random effects model**
Relative RD	-.0955391*	-.1763351*	NA
Relative SGA	-.1157691*	-.3251476*	.1450414
Relative advertising expense	-.6796165*	-.1973448	1.167375
Relative SGA and advertising expense	-.0838682	.0392417	-.0780742

Relative intangible assets	-.0612727	-.089495	-.1692985
Relative property, plant and equipment expenses	.0374039	.3957047	7.094697
Operating leverage	.0000258*	.0000263	NA
Debt-to-value ratio	.0308728	.0712912	.0288703
Relative intangible equity	-.0023527	-.0007183	-.0263855*

6.4 Robustness tests

Our first regressions indicated that the residual values were not normally distributed. Robust regressions were introduced to compensate for the heteroscedasticity, and rendered lower standard errors. Furthermore, when performing multiple regressions, a number of significant P-values were anticipated to display purely by chance. By using the Benjamini-Hochberg method, the p-values were recalculated to q-values with a q-value level indicating statistical significance at the $p<0.05$ level. The results of the Benjamini-Hochberg method did not change the significant parameters in the regressions conducted (see Table 6-11).

Hausman tests of the random effect the fixed effect regressions for the analyzed financial variables in Table 2 were conducted. The results indicated that fixed effect regressions were determined to better explain the findings of the variables relative R&D and relative SGA (Table 12, Appendix). In contrast, relative ADV and operating leverage were better explained by random effect regressions.

7. Implications and discussion

The aim of this study was to investigate factors that could predict stock returns in the US pharmaceutical industry, among them R&D expenses and financial parameters. The pharmaceutical industry in the United States is by many means different from other industries. It is characterized by high revenue potential together with high risk, as is exemplified by the high beta value and increasing volatility. The nature of developing a new drug is highly risky as evident from the high developing costs and the number of failed drug developments in different phases during the last decades. The innovation process leading up to a new drug is often characterized by a long process of research and development which in its nature is very risky and depends on a multitude of factors, for instance human resources, technology and sometimes pure chance. The complex industry architecture and the risks that are associated with the industry are sometimes hard to grasp for uninformed investors that are not familiar with the scientific issues of drug development. However, for investors, it is of vital importance to understand the pharmaceutical companies that they invest in, to better manage, diversify and hedge their portfolios.

Previous studies have shown that R&D is an important factor that influences returns, volatility and long term firm value in general. Several studies have shown that R&D expenses correlate positively with stock returns. In contrast, our results suggest that relative R&D does correlate negatively with stock returns. Possible explanations could be the time frame studied, the stock market and the selection of companies. The approach to study all companies from 1970 to 2015 may not fully reflect the present significance of R&D expenses, as the drug development period regularly spans between 8-12 years as IP issues are balanced against the R&D timeframe. Possible explanations for this trend may the outsourcing of R&D to smaller biotechnological companies and universities (Kneller et al., 2010). However, the completeness of the data set and the performed statistical analyses indicate the superiority of other variables compared to R&D expenses in assessing and predicting stock returns.

Interestingly, when comparing the pharmaceutical industry with the bank industry, several discrepancies are observed. To commence, the beta of all “Major Bank” stocks have a low beta value in comparison to “Major Pharmaceutical” stocks. Moreover, the lower volatility of the former is decreasing, in contrast to the higher and increasing volatility of the latter. This implies that we might expect an even higher volatility and thus increased stock returns in the pharmaceutical industry in the future, concordant with the strong evolution of the total assets of the pharmaceutical industry, reflecting the spending and investment in the

development of novel drugs.

Furthermore, the key financial parameters correlating with stock returns differ between the pharmaceutical and bank industries, which is expected. Interestingly, the variable relative intangible equity is significantly negatively correlated with bank industry stock returns, while it does not affect pharmaceutical stock returns. A reason could be that increased spending in intangible equity, e.g. patents and inventions do not reflect a positive value for the bank industry stocks in contrast to the pharmaceutical stock returns, where it is not significant. Previously, the pharmaceutical stock market in Iran was investigated, with special regard to financial variables affecting stock returns (kebriaeezadeh et al., 2013). It was found that debt-to-equity ratio was one positive explaining variable. In contrary, our analysis of debt-to-value ratio as a proxy for the debt-to-equity ratio showed no significant correlation with stock returns. The underlying reason for this difference could be due to the different stocks and time periods analyzed. In our investigation, 379 pharmaceutical companies are analyzed, in comparison to 39 companies in the previous study (kebriaeezadeh et al., 2013), thus suggesting that the debt-to-equity ratio may elicit a lower effect when increasing the number of companies.

Innovation measures, other than R&D, encompass variables reflecting the number of patents, ideas and theoretical research. A proxy could be intangible assets and intangible equity, defining the accounted value of inventions. In our investigation however, we could not find any correlation between intangible equity or assets explaining the pharmaceutical industry returns. This suggests that the correlation is not present or hard to determine statistically. In the latter case, the analysis of intangible assets could possibly be optimized by introducing more specific measurement of IP-related costs such as patents. However, such costs are often not accounted for in financial reports and may prove hard to evaluate, similar to the difficulties in exploring the effect of advertisement costs (Chauvin & Hirschey, 1993).

7.1 Suggestions for future studies

Other variables that have not been examined in this paper could in theory be predictors for cumulative stock returns in the pharmaceutical industry. Future research should investigate the impact of such variables. For example, a recent article reported that one important predictor of success of the drug development process can be therapeutic area of the compound of interest (Hay et al., 2014). For example the infectious disease area have higher approval rates compared to the field of endocrinology or neurology. Thus, analyzing if firms with certain field of drugs in their pipeline are more successful in the long run would provide

interesting insights. However, many firms have drug portfolios that encompass multiple therapeutic areas which could impede a comprehensive analysis of this variable.

Another aspect that could be analyzed in future studies is whether R&D expenses and its productivity differ between large and small pharmaceutical corporations. This could be analyzed by comparing subgroups of firms between each other and including small pharmaceutical companies in the data set.

7.2 Conclusions

This study investigated the pharmaceutical industry in the United States between year 1970 and 2015. In line with previous studies we found that net R&D expenses have indeed increased over the studied period. However, this was shown to be associated with a decrease in R&D productivity after fusion with FDA approval data. This implies that output of new drugs has stagnated despite the increased R&D spending. Therefore, our first hypothesis that the changing industry environment has affected R&D productivity cannot be rejected. In contrast to previous studies, we found that the variable R&D expenses is not a reliable predictor of stock returns and that it is in fact negatively correlated with stock returns. Consequently, the second hypothesis that R&D expenses are of decreasing importance cannot be rejected either. Furthermore, other variables were shown to explain stock returns, in some cases with more explanatory power than R&D expenses. Operating leverage was shown to positively correlate with stock returns, whereas, relative RD, relative SGA and relative advertising expenses were shown to negatively correlate with cumulative stock returns. Interestingly, none of these variables were significant in the banking industry. Several variables had no correlation with cumulative stock returns. Thus, the third hypothesis that financial parameters of firms can be predictors of stock returns is valid. To summarize, these results shed further light on the pharmaceutical industry in the United States and provide investors with novel information regarding important financial variables for understanding historical and predicting future stock returns.

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9. Appendix

Table 1: A. Regression of "Major Pharmaceutical" monthly stock returns against S&P 500 index returns. A. The beta value of "Major pharmaceuticals" was determined to 1.127. B. Regression of "Major Pharmaceutical" monthly trade volume against stock returns. A significant dependence between volume and stock return was found. C. Regression of "Major Pharmaceutical" yearly stock return volatility. The volatility was increasing over time.

	A	B	C
VARIABLES	Returns	Volume	Volatility
S&P500 returns	1.127***		
	(0.0234)		
Returns		69,873***	
		(12,538)	
Year			0.00296***
			(0.0001368)
Constant	0.00720***	168,066***	-5.721***
	(0.00101)	(2,829)	(0.5844)
Observations	47,766	46,493	4,240
R-squared	0.046	0.001	0.003

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 2: A. Regression of "Major Banks" monthly stock returns against S&P 500 index returns. A. The beta value of "Major banks" was determined to 0.623. B. Regression of "Major Banks" monthly trade volume against stock returns. A significant dependence between volume and stock return was not found. C. Regression of "Major Banks" yearly stock return volatility. The volatility was decreasing over time.

	A	B	C
VARIABLES	Returns	Volume	Volatility
S&P500 returns	0.623***		
	(0.00938)		
Returns		5.982	
		(13,388)	
Year			-0.000577***
			(0.00014)
Constant	0.00445***	34.357***	1.251***
	(0.000410)	(1.386)	(0.2724)
Observations	59.374	56.686	5.062
R-squared	0.069	0.000	0.041

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 3: Regression of R&D, relative R&D and returns over time. R&D costs as well as relative R&D costs were regressed over time. This was also conducted for returns. As evident from the table, there is a significant correlation between year and all of the three variables ($p<0.05$).

VARIABLES	R&D	Relative R&D	Returns
Year	6.34593*	.006019*	.0025647*
	(1.891423)	(.0005313)	(.00122)
Constant	-12236.29	-11.78147	-3.962006
	(3777.245)	(1.06174)	(2.441355)
p-value	0.001	0.000	0.036
Observations	2,249	2,249	2,274
R-squared	0.0016	0.0192	0.0008

Robust standard errors in parentheses. * $p<0.05$.

Table 4: Difference between total R&D expenses and stock returns over time. The regressions of total R&D expenses over time and stock returns over time were significantly separated.

VARIABLES	χ^2	p-value
Difference between total R&D and stock returns over time	11.25*	0.0008

* p<0.05.

Table 5: Random and fixed effect regressions of stock returns depending on relative R&D. The two time periods, 1970-1995 and 1995-2015, were analyzed in subgroups. Between 1970-1995, the random and fixed effect regressions coefficients between stock returns and R&D were positive but insignificant. However, between the years 1995-2015, the returns were negatively explained by relative R&D.

VARIABLES	Returns 1970-1995	Returns 1970-1995	Returns 1995-2015	Returns 1995-2015
Method of regression	Fixed effect	Random effect	Fixed effect	Random effect
Relative R&D	.1163995 (.3965096)	.1695394 (.2232006)	-.1829487* (.061817)	-.1082446* (.0463715)
Constant	1.120949 (.0560583)	1.124682 (.0455915)	1.253765 (.0282869)	1.230114 (.0246318)
p-value	0.769	0.448	0.003	0.020
Observations	274	274	1997	1997
R-squared	0.0004	0.0004	0.0052	0.0052

Robust standard errors in parentheses. * p<0.05.

Table 6: Random effects regression of financial variables against pharmaceutical stock returns. Relative R&D, relative SGA and relative ADV were negatively correlated with stock returns.

VARIABLES	Returns	Returns	Returns	Returns	Returns
Relative R&D	-.0955391*				
	(.0361226)				
Relative SGA		-.1157691*			
		(.0311346)			
Relative ADV			-.6796165*		
			(.207545)		
Relative SGA+ADV				-.0838682	
				(.0520224)	
Relative intangible assets					-.0612727
					(.0451003)
Constant	1.212484	1.227843	1.181464	1.188677	1.184801
	(.0190531)	(.0242212)	(.0297812)	(.0345501)	(.0264184)
p-value	0.008	0.000	0.001	0.108	0.174
q-value (* if q≤0,0222)	0.0222	0.0056	0.0111	0.0278	0.0333
Observations	2,249	1,403	582	522	1,778
R-squared	0.0021	0.0060	0.0066	0.0037	0.0006

Robust standard errors in paratheses. * $p<0.05$, corrected for multiple testing according to the q-values derived from the Benjamini-Hochberg procedure.

Table 7: Random effects regression of financial variables against pharmaceutical stock returns. Operating leverage was positively correlated with stock returns.

VARIABLES	Returns	Returns	Returns	Returns
Relative property, plant and equipment	.0374039 (.1490786)			
Operating leverage		.0000258* (8.13e-06)		
D/V-ratio			.0308728 (.044289)	
Relative intangible equity				-.0023527 (.0050494)
Constant	1.195943 (.0403379)	1.184728 (.0170593)	1.169172 (.0273636)	1.187713 (.0180523)
p-value	0.802	0.002	0.486	0.641
q-value (* if q≤0,0222)	0.0500	0.0167	0.0389	0.0444
Observations	1,094	1,986	2,274	2,239
R-squared	0.0001	0.0009	0.0003	0.0000

Robust standard errors in paratheses. * $p<0.05$, corrected for multiple testing according to the q-values derived from the Benjamini-Hochberg procedure.

Table 8: Random effects regression of financial variables against bank stock returns. No variables were correlated with stock returns.

VARIABLES	Returns	Returns	Returns	Returns	Returns
Relative R&D	-				
Relative SGA		.1450414			
		(.3190607)			
Relative ADV			1.167375		
			(3.756709)		
Relative SGA+ADV				-.0780742	
				(.3680041)	
Relative intangible assets					-.1692985
					(.1056872)
Constant	-	1.005393	1.007296	1.009861	1.009515
		(.0064453)	(.0033932)	(.0077179)	(.0022957)
p-value		0.649	0.756	0.832	0.109
q-value (* if q≤0,00714)		0,0357	0,0429	0,0500	0,0143
Observations		1,864	1,522	1,518	3,146
R-squared		0.0001	0.0001	0.0000	0.0009

Robust standard errors in paratheses. * $p<0.05$, corrected for multiple testing according to the q-values derived from the Benjamini-Hochberg procedure.

Table 9: Random effects regression of financial variables against bank stock returns.
Relative intangible equity was negatively correlated with stock returns.

VARIABLES	Returns	Returns	Returns	Returns
Relative property, plant and equipment	7.094697 (6.852469)			
Operating leverage		-		
D/V-ratio			.0288703 (.0431625)	
Relative intangible equity				-.0263855* (.0082729)
Constant	.7834688 (.1308786)	-	.9823284 (.0388281)	1.01099 (.0023933)
p-value	0.359		0.504	0.001
q-value (* if q≤0,00714)	0,0214		0,0286	0,0071
Observations	6		3,678	1,883
R-squared	0.2251		0.0002	0.0062

Robust standard errors in paratheses. * p<0.05, corrected for multiple testing according to the q-values derived from the Benjamini-Hochberg procedure.

Table 10: Fixed effects regression of financial variables against pharmaceutical stock returns. Relative R&D and relative SGA were negatively correlated with stock returns.

VARIABLES	Returns	Returns	Returns	Returns	Returns
Relative R&D	-.1763351* (.0581377)				
Relative SGA		-.3251476* (.0598137)			
Relative ADV			-.1973448 (.7552161)		
Relative SGA+ADV				.0392417 (.1381399)	
Relative intangible assets					-.089495 (.1056345)
Constant	1.236228 (.024954)	1.320769 (.0341391)	1.163648 (.0374104)	1.134583 (.0651661)	1.191021 (.031484)
p-value	0.002	0.000	0.794	0.776	0.397
q-value (* if q≤0,0111)	0.0111	0.0056	0.0444	0.0389	0.0333
Observations	2,249	1,403	582	522	1,778
R-squared within regression	0.0047	0.0243	0.0001	0.0002	0.0005

Standard errors in paratheses. * p<0.05, corrected for multiple testing according to the q-values derived from the Benjamini-Hochberg procedure.

Table 11: Fixed effects regression of financial variables against pharmaceutical stock returns. No variables were correlated with stock returns.

VARIABLES	Returns	Returns	Returns	Returns
Relative property, plant and equipment	.3957047 (.2266548)			
Operating leverage		.0000263 (.0000287)		
D/V-ratio			.0712912 (.0459912)	
Relative intangible equity				-.0007183 (.0083135)
Constant	1.126899 (.0530702)	1.18476 (.0173004)	1.150701 (.0276999)	1.187186 (.0184294)
p-value	0.081	0.359	0.121	0.931
q-value (* if q≤ 0,0111)	0.0167	0.0278	0.0222	0.0500
Observations	1,094	1,986	2,274	2,239
R-squared	0.0035	0.0005	0.0012	0.0000

Standard errors in paratheses. * p<0.05.

Table 12: Hausman test of financial variables against pharmaceutical stock returns. Relative R&D and relative SGA were significant, thus better explained by fixed effects regressions.

VARIABLES	Hausman χ^2	p-value
Relative R&D	4.37*	0.0366
Relative SGA	21.96*	<0.0001
Relative ADV	0.41	0.5210
Relative SGA+ADV	0.81	0.3674
Relative intangible assets	0.10	0.7495
Relative property, plant and equipment	3.77	0.0521
Operating leverage	0.00	0.9824
D/V-ratio	2.19	0.1391
Relative intangible equity	0.31	0.5770

* $p<0.05$.

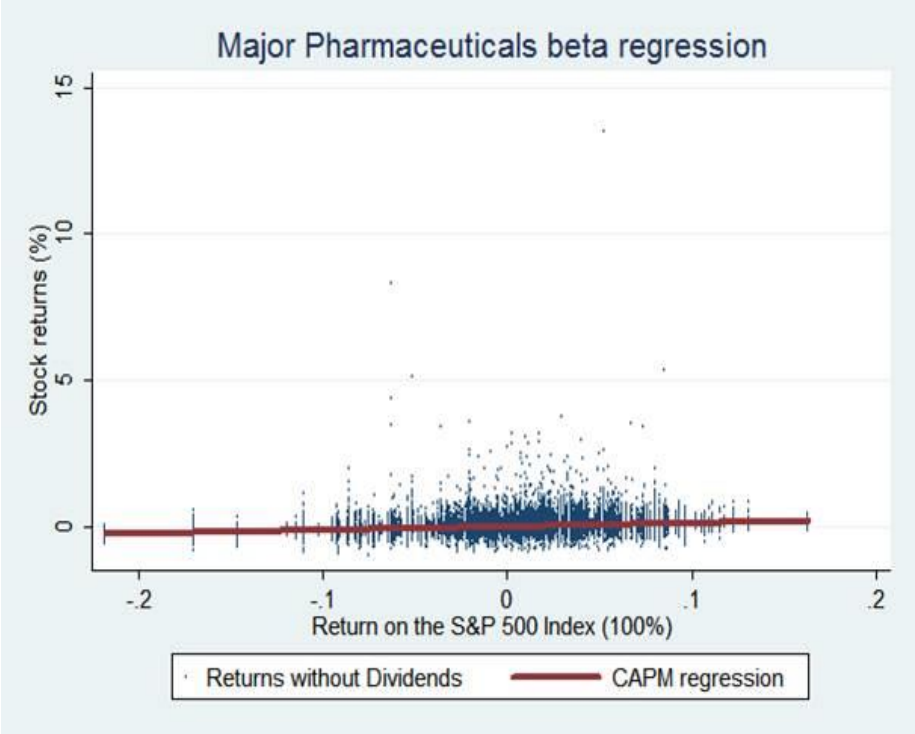

Figure 1: "Major Pharmaceuticals" beta regression. The beta value is 1.127.

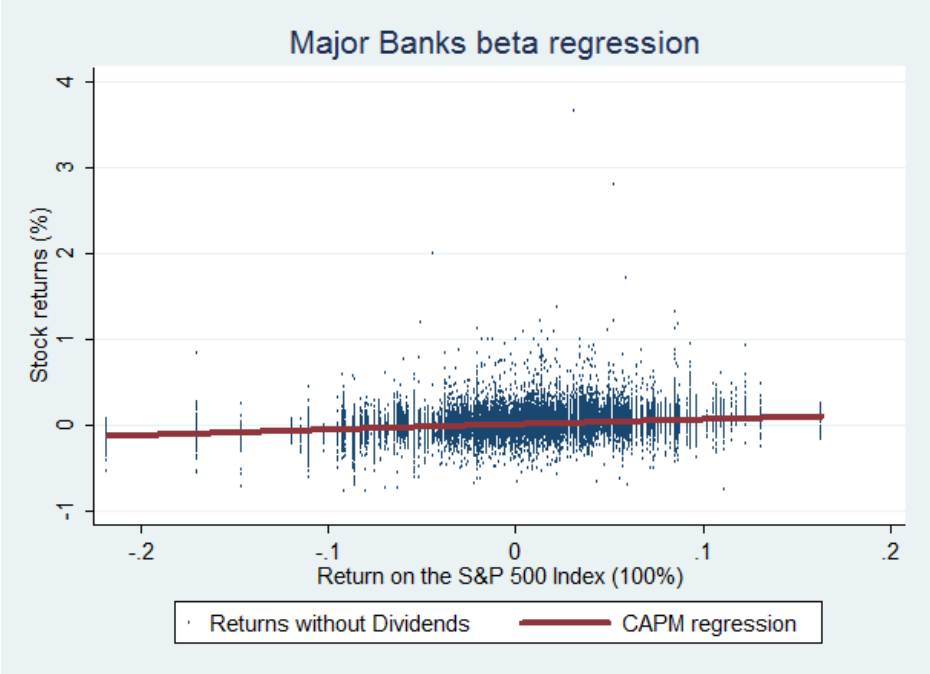

Figure 2: "Major Banks" beta regression. The beta value is 0.623.

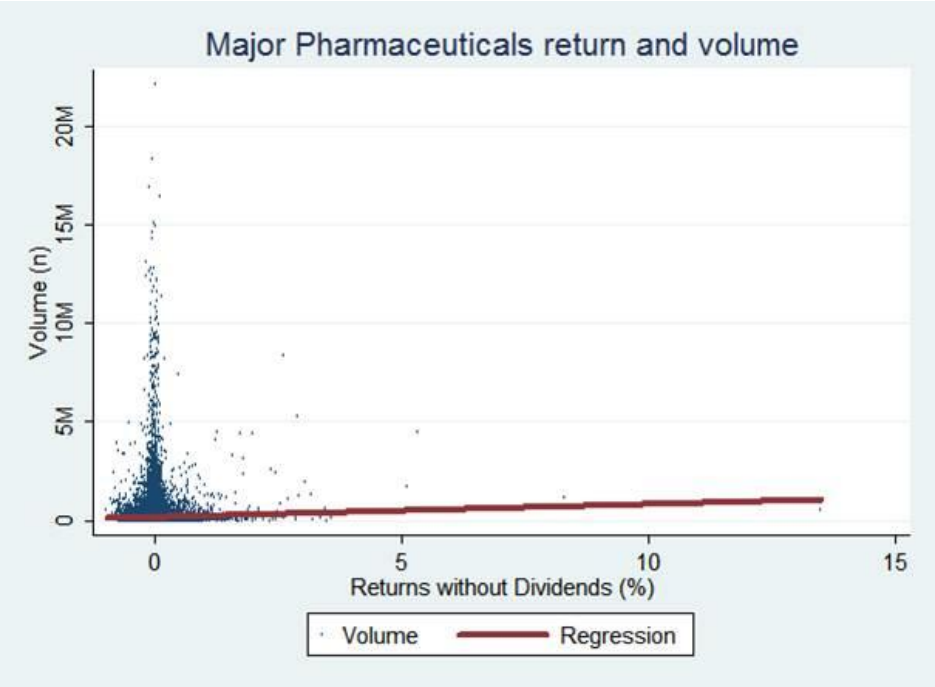

Figure 3: Volume as a function of return for "Major Pharmaceuticals".
The trade volume explains the stock return.

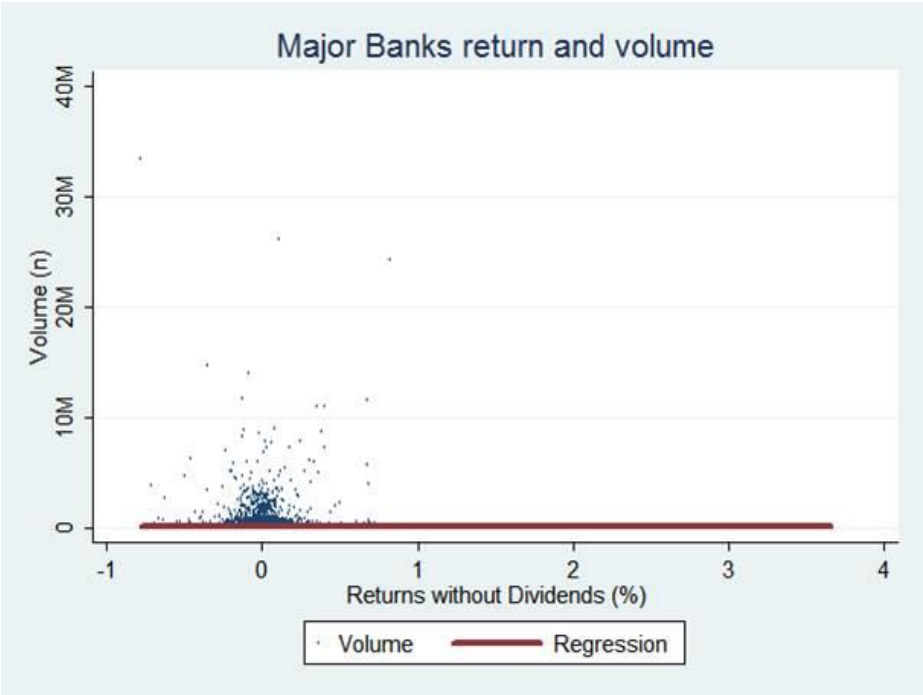

Figure 4: Volume as a function of return for "Major Banks".
The trade volume does not explain the stock return.

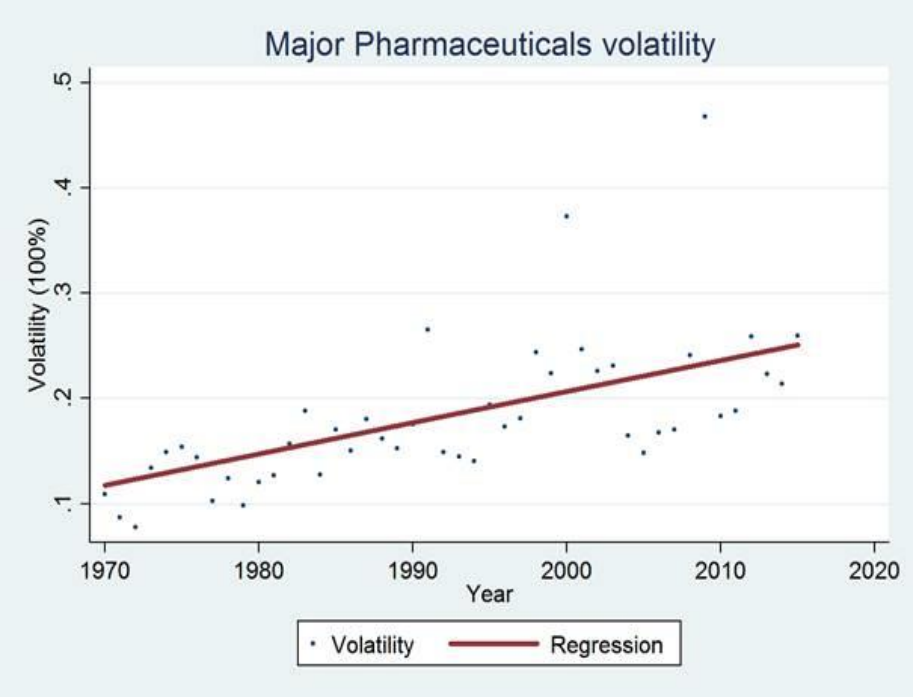

Figure 5: Volatility over time for "Major Pharmaceuticals".
The volatility increased over time.

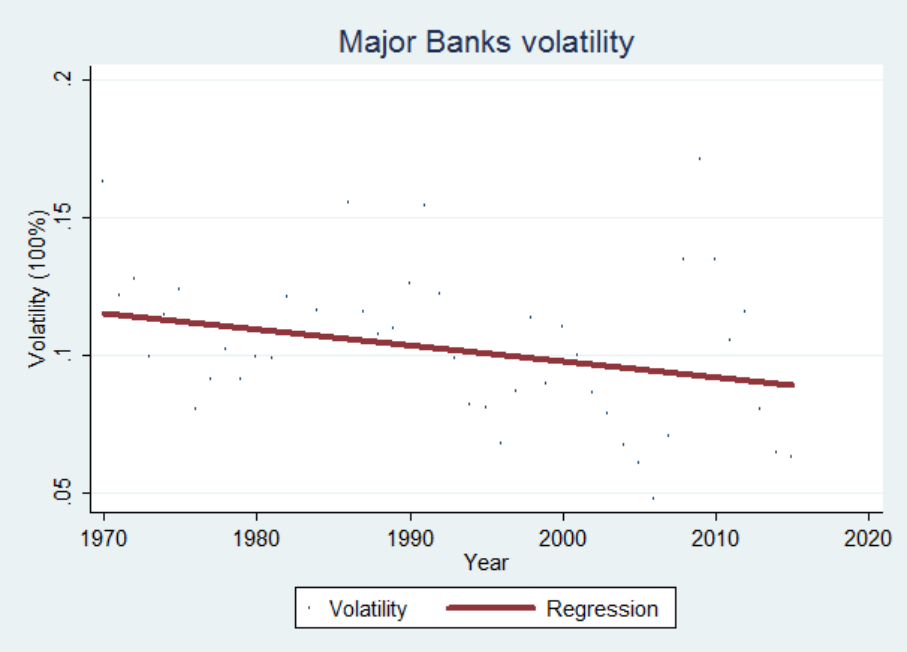

Figure 6: Volatility over time for "Major Banks".
The volatility decreased over time.