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R&D Investment Link to Profitability: A Pharmaceutical Industry Evaluation

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Abstract

This paper is an in depth analysis of the influence that investment into research and development has on a firm's profitability in the pharmaceutical industry in the United States. The pharmaceutical industry is chosen due to its high intensity of research and development expenditures. The top 16 companies in the pharmaceutical industry are analyzed through regression analysis. The argument made is that as more funds are invested into research and development a firm in the pharmaceutical industry will experience a higher market value. Theoretically as firms spend more on research and development they are increasing the likelihood of innovation, which will cause growth in the company. This study finds a positive and significant relationship between research and development expenditures and market value in the pharmaceutical industry.

Keywords

R&D, Innovation, Pharmaceutical

I. Introduction

Joseph Schumpeter stated in his book, Capitalism, Socialism and Democracy, that "the fundamental impulse that sets and keeps the capitalistic engine in motion comes from new consumer goods, new methods of production, and new markets" (Schumpeter, 1942, p. 83). According to Schumpeter, in order for firms to grow in a capitalistic economy, they must be competitive and innovative. Innovation is the process that generates goods and services that are of better quality and lower prices than their predecessors. Therefore, as firms innovate, they inevitably bring about an efficient allocation of the economy's resources and growth will occur. Innovation does not only lead to growth of a single firm, but innovation also improves the quality of life for all consumers in the economy.

The effect of innovation on firm growth has been studied intensely in the past. One way to measure this relationship is to examine the performance of sectors of the economy that specialize in innovation. If innovation does in fact lead to growth, then firms who innovate more should theoretically grow faster than those who do not. The goal of this paper is to study the efforts of firms who attempt to innovate. The research question of this paper is whether firms who spend more funds on research and development expenditures become more profitable than firms who spend less on research and development expenditures.

The reason for using research and development expenditures as a measure of innovation by a firm is that as firms spend more funds on research and development they are providing their researchers with more resources at their disposal, which should result in a better likelihood of innovating successfully. When firms innovate, they receive patents, which give them a temporary monopoly over the market, which provides excess profits. The excess profits will in turn raise market value. If a positive correlation is found between market value and research and development expenditures, it will give support that innovation is in fact a driving force of a capitalistic economy as stated by Schumpeter.

There are two forms of innovation within manufacturing firms. The first type is called process innovation. Here, a firm innovates the way that they produce goods. They increase their total factor productivity. Another form is product innovation where firms either create entirely new products, or greatly improve an existing product. The focus of this paper will be on product innovation within the pharmaceutical industry.

There is a large and increasing demand for innovation within the pharmaceutical industry in today's economy. With an aging population, and an estimated life expectancy in the United States of now 78 years, consumers are constantly demanding new pharmaceutical products to aid them in their daily lives (The World Bank). The pharmaceutical industry has enormous costs in product development. The estimated costs of discovering, developing, and launching a new drug was 1.7 billion dollars in 2003 (Bain and Company, 2003). In 2006 global spending on pharmaceuticals rose 7% from 2005 to over $600 billion dollars, and the United States is reported to spending nearly half of that, at $252 billion (Herper, 2006). With this high spending, and high need for product innovation, the pharmaceutical industry should prove to be a viable selection for this study.

The pharmaceutical industry has a number of essential characteristics that this study needs. First of all, the pharmaceutical industry has a high rate of innovation. Secondly data on firms within the pharmaceutical industry are accessible because they are public information. Many websites, including MSN.com, Yahoo.com, as well as the websites for each firm, display financial statements for the public companies that are included within this study. It will be necessary to acquire a number of control variables from financial statements from over 10 years

ago due to a necessary lag, and the financial statements from the companies within the pharmaceutical industry can provide this data. The last essential characteristic of the pharmaceutical industry is that not only is there a high rate of innovation, but the cost of innovation is high, and innovation is vital to the survival of companies within the industry (Ellison, 2008). Therefore, it will be interesting to discover if there is indeed a relationship between R&D expenditures and market value for the pharmaceutical industry.

As stated previously, this paper will evaluate the link between research and development expenditures and profitability. It will do so empirically through regression analysis as well as descriptive statistics. Yearly data will be gathered from the top 16 grossing pharmaceutical companies in the United States and a panel dataset will be constructed dating from 2004 to 2007, with a lag of 10 years for research and development expenditures. The control variables used are market share, firm growth, free cash flow, and the standard deviation in share price of the previous three years in order to control for risk. The findings of this paper are that research and development expenditures, as well as free cash flow, have a positive and significant effect on market value. Risk has a significant and negative effect on market value. Market share and firm growth proved to be insignificant.

The rest of the paper is organized as follows. A literature review explaining past studies and what has been done within this area of research is presented in Section II. The theory of this paper, explaining the economic reasons for the relationship between research and development expenditures and profitability, is presented in Section III. Additionally this section will develop an appropriate and testable hypothesis. Section IV presents the empirical model and explains all of the variables. The data, its origination, and descriptive statistics are discussed in Section V. Section VI presents the regression results. Finally Section VII concludes the paper and discusses possible avenues of future research.

II. Literature Review

It has been argued that the advancement of technology is the engine that powers capitalism. Firms who innovate will grow and those who do not will remain stagnant (Rzakhanov, 2004). In a capitalistic economy the need to stay ahead of the curb is essential for firm performance, especially in highly intensive R&D industries. The decisions that firm management makes regarding R&D investment can affect growth, sustainability, and reputation. The spending on research and development is no longer being looked at as a cost for the firm, but a value-increasing investment to the firm (Pindado, 2010).

There are two types of innovation in manufacturing firms which either aim to improve production techniques or create new products. Typically most firms engage in both types of innovation. As described in Plehn-Dujowich (2009), firms may increase their total factor productivity through process research and development spending. The innovation here can lead to an increase in profits simply by increasing the supply of units that are produced and sold. Another type of innovation is the creation of entirely new products, which is accomplished through product research and development. The creation of new products may lead to a new market which the innovating firm would have control over. The new market will create profits for the firm and growth will occur. Both of these types of innovation are included on financial statements by firms and are recorded as research and development expenditures.

According to Cohen and Klepper (1996), smaller firms aim to innovate more through product innovation, while larger firms attempt to innovate more through process innovation. The reasoning behind this is that larger firms have more capital and can broaden their R&D costs to a

greater degree than smaller firms. Moreover, since larger firms have a larger market, they will benefit more from the cost reduction generated through process innovation.

Past studies have shown that research and development expenditures have consistently and positively affected the profitability of a firm ([Ehie, 2010], [Pindado, 2010], [Shah, 2008], [Roberts, 2001], [Chan, 2001]). Roberts (2001) explains that as firms innovate, create new products, and bring them to market, they have a temporary monopoly in that they are the only ones supplying the new product. According to classic economic theory, if there are profits to be made, then new firms will enter the market and drive the market back to equilibrium thereby eliminating excess profits. However, Roberts (2001) explains that a firm could earn persistent profits by either continuing their innovation, or by limiting competitor imitation of the new product through barriers to entry. Many technological firms achieve this through patents.

Additionally, as firms innovate and create new ways of producing, they may be able to create more products at a reduced cost. The savings here may lead to a larger bottom line and therefore more profits. The ability to innovate production capabilities in manufacturing firms may not only lead to a reduction of costs in current production but may also lead to a reduction of fixed costs for the firm. If firms are able to produce more units given their existing capacities and the demand for the product increases, the firm may not need to buy more space to produce because they are already producing more units with the space that they have (Evengelista, 2010).

Firm profitability can be measured in many ways, but the general consensus that arises from past research is through market value ([Ehie, 2010], [Shah, 2008], [Chan, 2001]). The market value of a firm is calculated as share price multiplied by the number of outstanding shares, (Shah 2008). According to Chan (2001) p. 2431, "The market value of a firm's shares ultimately reflects the value of all its net assets." Chan (2001) goes on to argue that the relationship between market value and tangible assets is clear. However, the linkage between market value and intangible assets is somewhat harder to determine. For example the benefits of research and development expenditure, a type of intangible asset, cannot be appropriated today, but will occur several years from now. Investors must adjust their evaluation of a firm's profitability off of assumptions and expectations of how research and development expenditures will affect the firm's profits in the future. Additionally, if research and development expenditures do not yield successful innovation, a firm's profits will fall and their market value will decline.

In order to measure the influence that research and development has on the market value of a firm, past studies have analyzed large pools of companies and then compared different industries within the index, ([Chan, 2001], [Shah, 2008], [Ehie, 2010], [Rzakhanov, 2004]). For example Chan (2001) evaluated American manufacturing firms, dating from 1975 to 1995. Similarly, Shah (2008) evaluated UK manufacturing firms from 1998 to 2002.

Shah (2008) took a pool of 1794 firm observations who all had research and development spending. This paper found that the top two R&D intensity industries were pharmaceuticals/biotechnology, as well as electronic and electrical equipment. These two industries accounted for more than 50% of the total R&D expenditures in the sample. This paper evaluated these two sectors specifically and found a positive correlation between research and development expenditures and market value.

Chan (2001), instead, separated the data into quintiles depending on their R&D investment intensity and also found that pharmaceuticals and electronic firms have high research and development intensity. This paper analyzed the difference in stock returns for different R&D intensified firms to see if industries with higher R&D intensity grow faster than those with lower R&D intensity. The findings were that the average annual return was 19.65% for all firms in the

data set, while the highest R&D invested firms in the top quintile had an average annual return of 19.52%.

The findings in Chan (2001) argue that industries with higher intensified R&D efforts do not grow faster than industries that focus less on R&D. However, within an industry that has high research and development costs and expenditures, for example the biotechnology industry, where research and development is such an important aspect of their business, do markets correctly assess the value of intangible assets? This question was analyzed in the past by Rzakhanov (2004).

Rzakhanov (2004) found that financial markets do in fact take into account intangible assets when evaluating firm value. The paper focused on the biotechnology industry over the period from 1980 to 2000. The number of patents that a firm produced was used as a measure of successful innovation. Rzankhanov (2004) found a positive and significant relationship between obtaining patents and market value. Therefore, biotech firms who were more successful in their research and development attempts were valued higher than firms who failed to do so.

Pindado (2010) measured how firm characteristics could affect the relationship between R&D investment and firm value. This paper found the main factors which affected the relationship to be firm size, firm growth, free cash flow, market share, external financial dependence, labor intensity, and capital intensity. While firm size, as well as growth and market share, were found to have a positive relationship with investment in R&D, external financial dependence, capital intensity, labor intensity, and free cash flow were found to have negative effects. Many of the firm characteristics measured in Pindado (2010) have also been used as control variables in other papers ([Rhzakhanov, 2004], [Ehie, 2010], [Chan, 2001], [Chauvin and Hirschey, 2001], and [Shah, 2008]).

Interestingly, Shah (2008) argued that advertizing may also affect the relationship between R&D investment and firm value since, those firms who advertize more allow their products to become more well-known. Chauvin and Hirschey (2001) agree and state that "advertizing and research and development expenditures have large, positive and consistent influences on the market value of a firm" (p. 128). Although advertizing has been shown to have a significant impact on market value through increasing the profitability of a firm, advertizing expenditures tend to be difficult to obtain, since the expenditure is not required to be stated on a firm's financial statement.

Another important point that has been addressed in past research is that as research and development expenditures increase, the volatility of returns increase as well ([Chan, 2001], [Shah, 2008] and [Ehie, 2010]). According to Chan (2001) there is no difference in returns for firms who spend a lot on research and development and those that spend a little, which may imply that research and development expenditures do not affect firm performance much. However, the paper goes on to argue that "R&D may have effects on firms' financial performance beyond average stock returns" (p. 2452). This paper argues that there is a high degree of uncertainty surrounding R&D intensive firms' future profits due to no clear understanding of how research and development expenditures will pan out. The paper estimated the standard deviation of monthly returns based on the past 12 months. A regression was then run which related the stock market return standard deviation to the following variables: the firm's stock market capitalization, the firm's age, as well as the firm's R&D intensity relative to its sales. Chan (2001) concluded that when compared to firms with little R&D spending, those firms who do spend more on R&D may experience more volatile returns. Therefore, the volatility of returns may rise with R&D spending according to Chan (2001).

Past research has shed light on a number of important factors that this paper will incorporate. In the following section an appropriate hypothesis will be developed, based on the findings from previous studies. Theory surrounding the topic will also be included and will be incorporated in the development of the formal hypothesis.

III. Theory

The purpose of this paper is to analyze whether or not firms who invest more funds into research and development experience a higher market value than those firms who spend less. The paper will use past literature to develop an appropriate and testable hypothesis. Schumpeter's theory of creative destruction will also provide support for the research question.

Past literature has repeatedly shown a positive and significant correlation between research and development expenditures and firm value ([Ehie, 2010], [Pindado, 2010], [Shah, 2008], [Roberts, 2001], [Chan, 2001]). This paper will differ from these past research papers in that it will focus on one specific sector of the economy which has a high rate of innovation, and high intensity in research and development expenditures. The pharmaceutical industry has been shown to have both of these characteristics, as well as easily accessible data.

The basis of this paper is derived from Schumpeterian economics. In Schumpeter's book, Capitalism, Socialism and Democracy, Schumpeter argues that innovation drives the economy under capitalism. Schumpeter describes this process as creative destruction. When new products are introduced that are of better quality than their predecessors, they eliminate the market for the original product and create a new market. Therefore, in industries where new products are introduced often, innovation is essential to each firm's survival.

The creation of new products, and hence new markets, gives a firm a competitive advantage in the market and allows the firm to earn excess profits. Firms who consistently innovate can have persistent profits. As new markets are created, other firms will attempt to imitate the product in order to drive the excess profits down. The success of the imitation will depend heavily on restrictions to copy other firms' products. Those restrictions will typically come in the form of patents, and the characteristics of patents within the industry. If there are heavy restrictions, the firm who innovated should have a higher market value than they previously had, because they are now more profitable. Once patents expire however, the firm who originally invented the product will need to innovate further in order to remain competitive and keep their market value high. The need to continuously innovate drives competition in higher innovative sectors of the economy (Roberts, 2001).

Firms attempt to innovate by doing research. The amount of funds that are poured into research should reflect the success of the research projects. For example a research project with a 1 million dollar investment may come back with a good product. However, a firm who invests 10 million dollars into their research project should have a good chance at creating a better product than the other firm because it has more resources at its disposal. The positive correlation between profitability and acquiring patents has been shown in past literature (Rzakhanov, 2004). Therefore, if acquiring patents increases a firm's market value, and spending more funds on research and development gives firms a better likelihood to innovate, then spending more funds on research and development should increase a firm's market value.

As proposed by Chan (2001) there exists an element of risk when firms invest in research and development because of the uncertain profits that the research and development investments may bring. However, even with this uncertain outlook, theoretically, firms will still have a strong incentive to invest heavily in research and development because the reward of doing so should heavily outweigh the possible losses.

The above discussion suggests that the greater intensity on research and development should increase a firm's innovation capabilities and therefore could possibly increase the firm's profitability. Accordingly, the formal hypothesis of this paper is as follows.

Hypothesis: Investment in research and development has a positive effect on the market value of a firm.

IV. Empirical Model

This paper will investigate the hypothesis stated above empirically through regression analysis and the model used to test the research question will now be presented. Based on previous research, the dependent variable of the model is market value, and the independent variable is research and development expenditures. The control variables used in this study are firm growth, free cash flow, market share, and risk. The regression equation for the analysis is the following.

Equation: Market Value/Revenue = $\beta_1 + \beta_2$(R&D/Revenue) + β_3(Growth) + β_4(Free Cash Flow/Revenue) + β_5(Market Share) + β_6(Size) + e

Market value for each company will be calculated by taking the share price of the firm multiplied by shares outstanding. The share price of a firm should encompass investor's expectations of future cash flows of the company. As a measurement for profitability, market value is appropriate because it encompasses not only future expected net cash flows, but also the volume of shares that a firm has. Market share will be normalized in the regression analysis by dividing by total sales. The normalization creates a control for firm size and also allows for an easier interpretation of the results of the regression analysis.

Research and development expenditures are predicted as having a positive impact on market value. This variable will measure the total amount of expenditures on all research and development projects taken in one year. In order to control for differences in the size of the firms, however, R&D will be normalized by dividing R&D expenditures by sales revenue. Additionally, R&D will be lagged by ten years. Within the pharmaceutical industry there are three clinical phases in which new drugs must go through in order to get approved by the Food & Drug Administration. It is estimated that the three clinical phases can take anywhere from 10 to 15 years. R&D expenditures today will not affect the market value of the firm until the R&D investment is realized, hence the lag of 10 years (DiMasi, 2002).

Firm growth is predicted as having a positive effect on the market value of a firm. If a firm is growing more relative to another firm then they will be shown to be more successful in past investments and business strategy. The successfulness here will be shown in the market place when investors place a higher market value on that firm than other firms. Not only does firm growth show past successfulness of a firm, but also a sign of what is to come. If a firm has had success in business ventures in the past, it is a good sign that management and the firm employees will continue to be successful in the future. Firm growth will be calculated as the average percent change in sales from year to year of the previous three years for the firm. The three year period was chosen because it is the standard in measuring the financial status of a firm as shown in the Domadaran database as well as other papers [(Pindado, 2010), (Chauvin and Hirschey, 2001)].

Past literature has found that free cash flow has both a positive and negative effect on market value. Pindado (2010) explains that free cash is, "the cash flow in excess of that required to fund all net present value projects when discounted at the relevant cost of capital" p. 763. Pindado (2010) argues that free cash flow should have a negative effect on market value. The

paper explains that when firms have a high level of free cash flow they tend to use these funds in negative net present value projects. In other words, firms with a higher free cash flow tend to take more risks. Chauvin and Hirschey (2001), on the other hand, argue that free cash flow should have a positive effect on the market value of a firm. The paper argues this by explaining that the current cash flow of a company is the best indicator of a firm's ability to generate future cash flows. This paper will expect the latter and predict that free cash flows will have a positive effect on market value. The pharmaceutical industry is one that relies on innovation. Thus, it seems more logical that firms who have higher free cash flows would use these funds in an appropriate manor and not take unnecessary risks. In the regression analysis free cash flow will be normalized by dividing by total sales. The normalization will allow for a size control as well as provide an easier interpretation of the regression results.

Market share is predicted as having a positive effect on the market value for each firm. As a firm gains market share and becomes larger, they will be less affected by events occurring in the economy due to them having more capital. Larger firms should also be more flexible and able to disperse their capital in a better manner than smaller firms. The market share will be measured as the total sales of a firm divided by the total sales of all firms within the data set for a given year.

Risk is predicted as having a negative effect on market value. A firm's ability to generate future profits will be more uncertain for a firm that has more volatility in their stock price than firms with more stable stock prices. The risk variable is thus calculated as the standard deviation of the stock price over the previous three years. The reason for considering three years is to capture the most relevant financial status of the firm, and three years is the standard in doing so. A summary of all of the variables in this study is provided below in Table 1.

Table 1. Description of Variables

Variable	Definition	Expected sign
Dependent Variable-		
Market Value	Stock price multiplied by number of outstanding shares / total sales revenue	
Explanatory variables-		
Main Focus		
Research and development expenditures	Amount of dollars spent on R&D / total sales revenue	+
Control Variables		
Firm Growth	Change in yearly revenue averaged over the previous 3 years	+
Free Cash Flow	Free cash flow calculated from financial statements / total sales revenue	+
Market Share	Total sales revenue of individual firm / total sales of all firms	+
Risk	Standard deviation of stock price of previous 3 years	-

V. Data

As previously stated, this study investigates the research question from the perspective of the pharmaceutical industry. The dataset thus consists of the 16 largest pharmaceutical firms in the United States, as of the end of the year 2008. Some of these companies include Pfizer, Johnson and Johnson, and Merck & Company and all of these companies have significant research and development expenditures. For a complete list of the companies used in the dataset refer to Appendix A. From these 16 firms a panel dataset was created covering the years 2007 to

2009. The total sample size of the dataset is thus 48. A scatter plot is shown for the dataset in Appendix B. An interesting thing to note about the scatter plot is the dispersion of the observations as research and development percentage to sales increases. The increase in the variance in the data as R&D to sales increase could result in heteroskedasticity, and should be corrected for in the regression analysis.

The reason for using the period 2007 to 2009 is to control for economic fluctuations. According to the National Bureau of Economic Research, the recent recession began on December 1st, 2007 and ended on June 1st, 2009. In order for this research to be complete it would be best to study an entire economic cycle. In fact, the most recent economic expansion began in 2001 and ended with the start of the recent recession. However, due to time constraints and limitations on data availability, this study will only consider the most recent recession, the time period of 2001 to 2009. As previously stated, research and development expenditures are lagged 10 years. Thus the data on R&D covers the years from 1997 to 1999.

The firms included in this study were chosen based on CNNMoney.com's global500 list of the largest companies in the world in terms of sales. Given the inconsistent availability of data from financial reports, this study was forced to gather data from a few different sources online: MSN.com/money, Yahoo.com/money, as well as financial statements from each firm's website. Research and development expenditures were obtained from financial statements from firms' websites. Market value, market share, sales, firm growth, and free cash flow were collected from MSN.com/money and Yahoo.com/money. Finally, risk was gathered from the Domadaran online database.

A brief snapshot of the data is shown below in Table 2, which provides descriptive statistics of the data. The median, standard deviation, minimum and maximum values of each variable are listed. Please note that market value, research and development, and free cash flow are not normalized, but measured in millions of US dollars. The reason for this is to offer a clearer understanding of the descriptive statistics of these variables. The descriptive statistics of the normalized variables are reported in Appendix B.

Table 2. Descriptive Statistics with No Normalization

Variable	Median	Standard Dev.	Min	Max
Market Value	$38,000.43	$51,180.60	$3,060.02	$198,290.60
R&D	$245.70	$876.81	$16.66	$2,776.00
Firm Growth	10.26%	13.41%	-6.84%	59.46%
Free Cash Flow	$8,765.94	$23,798.35	$1,245.56	$96,105.00
Market Share	3.66%	6.59%	0.70%	24.70%
Risk	23.42	6.04	10.47	37.42
Dollar amounts are in millions				

The median market value for the dataset is 3.8 billion dollars. The largest firm in the dataset has a market value of 19.8 billion and the smallest firm has a value of 306 million dollars. It is interesting to notice the large gap between the largest and the smallest companies considering a small dataset of only 16 firms. The difference here shows the necessity to control for size within the dataset. It is also interesting to see how much larger firms spend on research and development as compared to smaller firms. Note the large amount of research and development expenditures. As previously stated, it typically takes 1.7 billion dollars over the life of a drug to research, develop, and bring it to market. The largest amount of research and

development by a firm in one year is nearly 2.8 billion dollars. The median amount of spending in one year by a firm is 245 million dollars. The huge spending by firms within this industry shows that firms are indeed attempting to innovate.

VI. Results

Once the dataset was created, an OLS regression was run in SPSS. The original OLS regression was tested for heteroskedasticity by running a White's test and unfortunately heteroskedasticity was found and corrected for by using robust standard errors in Stata. Robust standard errors assume homoskedasticity, therefore allowing for a precise measurement of the significance of the variables. Please see Appendix B for the results of the White's test. The original model results not corrected for heteroskedasticity are also provided in Appendix B. Table 3 below shows the regression results, which have been corrected for heteroskedasticity.

Table 3. Regression Results

Variable name	Original Model	No Firm Growth	No Market Share
Constant	33.79** (2.19)	37.61** (2.67)	28.23*** (3.78)
Normalized Research and Development	.279* (1.75)	.315* (1.96)	.287* (1.79)
Firm Growth	.259 (.83)		.288 (.97)
Normalized Free Cash Flow	.185*** (3.17)	.160** (2.56)	.179*** (3.32)
Market Share	-.284 (-0.57)	-.407 (.377)	
Risk	-1.349* (-1.81)	-1.24 (-1.59)	-1.18** (-2.24)
Adjusted R-squared	.497	.475	.497
N	48	48	48

Significance level at .10* .05 .01*** t-statistics in parentheses**

The first thing to note when considering the regression results of the original model is that the R&D coefficient is significant and has the correct sign. In fact, all coefficients, except for market share have the predicted sign. Unfortunately, not all of them are significant. In fact, market share and firm growth are highly insignificant. The insignificance of firm growth has also been seen in other papers (Chauvin and Hirschey, 2001). A second model was run which did not include firm growth in order to test for multicollinearity. As can be seen in the results, the significance of the coefficients does not improve and nor do the values of the coefficients change much. Theoretically, though, it makes sense to keep firm growth in the model because there should be a control for firms who are growing more relative to other firms. In the pharmaceutical industry, where innovation is essential to the growth of a firm, the recent growth of the firm should reveal the success of the innovation attempts by the firm. If the firm is successful in innovating, then they should have a higher market value. Therefore, firm growth is reentered into the model.

Going back to the original model, the coefficient for market share was found to be insignificant. Originally market share was put into the model in order to control for firm size. However, since market value, research and development, and free cash flows are normalized by dividing by sales revenue, it may not be necessary to include another variable that controls for

size. Therefore, market share is removed from the model and this version of the model will be the final one, and the one that is analyzed.

Research and development is shown to have a positive and significant effect on market value in the final model at the 10% level. The findings here are concurrent with the past findings [(Chauvin and Hirschey, 2001), (Ehie, 2010), (Rzakhanov, 2004), (Shah, 2008), and (Chan, 2001)]. The findings from this paper, however, focus primarily on the pharmaceutical sector of the economy. According to the final model, an increase of one dollar in research and development spending per sales dollar, will lead to a 29 cent increase in market value per sales dollar. The results here are interesting when looked at on a larger scale. The highest amount spent on research and development in the dataset was nearly 2.8 billion dollars. The lowest amount spend on R&D was 17 million. According to the regression results, the firm who spent the largest amount should have a market value that is 807 million dollars higher than the firm who spent the smallest amount. The actual data reports that the largest spender on R&D had a market value of 124 billion dollars, where the lowest spender had a market value of 5 billion.

Risk is shown to have a negative and significant correlation with market value in the final model at the 5% level. The coefficient for risk is 1.18. This means that for a change in the standard deviation in the stock price of a firm over the previous 3 years of one, market value per sales dollar will fall by $1.18. The findings here are important because they demonstrate the factor of uncertainty within the industry that can arise from failing to create a new drug, get it approved by the Food and Drug Administration, or even having a drug taken off of the market. As the results show, the riskier the firm is, the less their market price will be valued. The negative and significant coefficient is concurrent with the findings in Chan (2001), Shah (2008) and Ehie (2010).

Normalized free cash flow is significant in the final model at the 1% level. This shows that a change of one dollar in free cash flows per sales dollar will lead to a positive change of 18 cents in market value per sales dollar. The findings here are concurrent with the findings in Chauvin and Hirschey (2001), but disagree with the results in Pindado (2010). Chauvin and Hirschey explained that free cash flows is an indication of the firm's ability to generate future cash flows. On the other hand, Pindado (2010) argued that too much free cash flows would lead to investments in negative net present value projects. For the pharmaceutical industry, where investment into research and development is so crucial to the growth of the firm, Pindado's conclusions have less relevance.

The results show that research and development expenditures do have a positive and significant effect on the market value of a firm. However, risk also plays a significant and negative role. Therefore, when management of a pharmaceutical firm is considering possible investment strategies it is important to find the most profitable ways to invest into research and development. Spending more money than your competitor will earn you a higher market value, assuming that you spend wisely.

VII. Conclusion

This paper investigated whether or not research and development expenditures have a positive and significant effect on market value from the perspective of the pharmaceutical industry. Sixteen of the largest companies in the United States were evaluated through regression analysis. Heteroskedasticity was found and corrected for. This paper finds that research and development expenditures have a significant and positive effect on the market value of a

pharmaceutical company. As firms spend funds on research and development, they should, on average, expect a higher market value the more that they spend. Risk is confirmed as having a negative and significant effect on market value, which means that as firms spend more on research and development, they should invest wisely because mistakes are not forgiven in the market place. Free cash flow was shown to be the most significant variable in the results. It had a positive sign which shows that firms who have a higher free cash flow will have a higher market value.

Given the time constraints of this study, there are several areas in which to expand this line of research. First of all, the study would be more complete with a larger dataset. This could be achieved by including more companies, and by increasing the years over which this study focused. In addition, it is interesting that firm growth was shown to be insignificant. The theory is sound, so firm growth is included in the model. Future research will need to reevaluate how firm growth is measured. Future research could also focus on process innovation, rather than focusing primarily on product innovation. It would be interesting to compare two industries' investments in research and development where one industry's focus is product innovation while the other is process innovation.

Other issues have also been shown to have an effect on market value and could be included as control variables. Advertising should have a significant and positive effect on market value because as firms spend more on advertising, their product becomes well known, and more people should consume it. Patents should have a positive and significant impact on market value as well. As firms obtain more patents relative to other firms, it is a signal of their innovative achievements, indicating the successful means of the company.

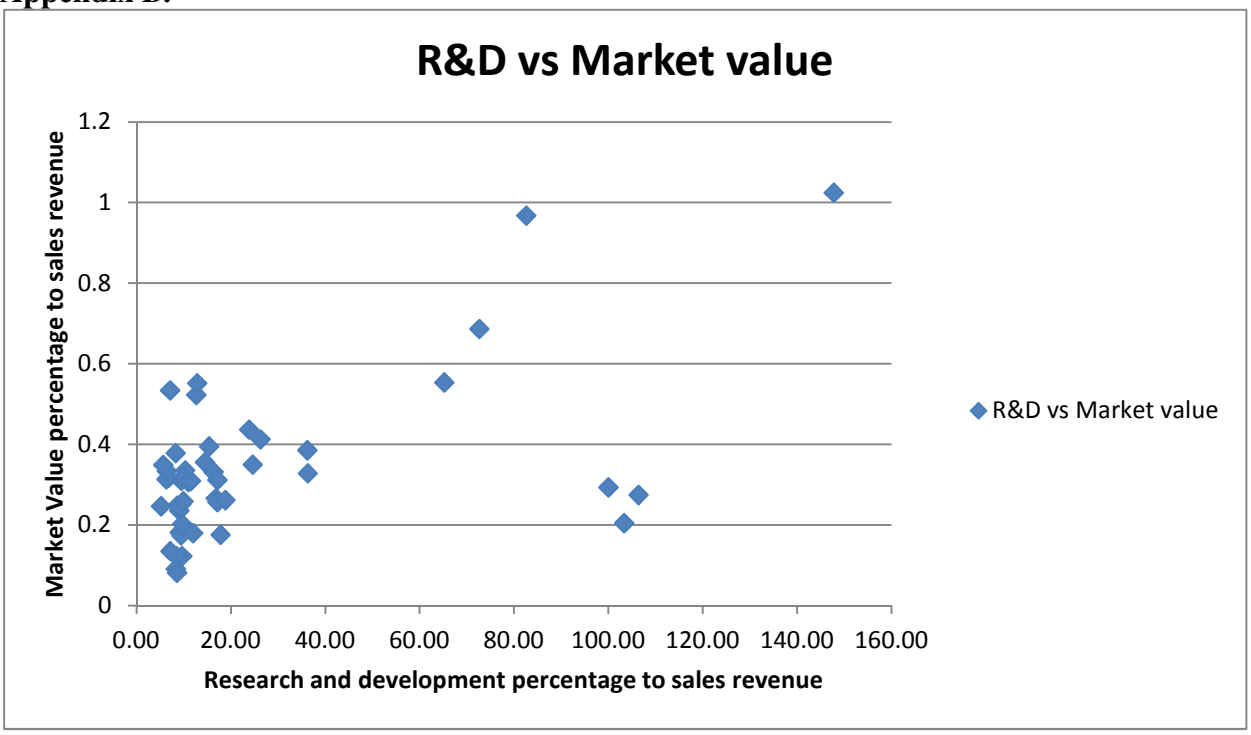
There is also another interesting direction in which to expand this study that is relevant to current events. There is currently a large discussion within congress on the life of patents and how long they should be. The pharmaceutical industry has the second largest group of lobbyists in congress today, and this is largely due to patent life. The life of a patent is important because it gives the firm exclusive rights to the technology in producing their product and the technology for new products. As the life of a patent is shortened, it decreases the profits of the firm because generics will now be available sooner, which may decrease the price of the product. This will positively impact the consumer because they are able to save money. However, as profits shrink for the innovative firm, this may decrease the amount that the firm spends on research and development because the return on investment is smaller. As firms spend less on research and development, this could lead to a decrease in innovation, which will negatively impact the consumer. It would thus be exciting to extend this study to focus on the effect that patent life has on the investments made by firms on research and development.

Appendix A: Pharmaceutical Companies in Dataset in order of sales revenue as of 2008

Pfizer
Johnson and Johnson
Abbott Laboratories
Merck & Co.
Bristol-Myers Squibb
Eli Lilly and Company

Baxter International
Forest Laboratories
Genzyme
Gilead Sciences
Allergan
Biogen Idec
Watson Pharmaceuticals
Mylan Laboratories
Cephalon
Amgen

Appendix B.



Descriptive Statistics with normalization				
Variable	Median	Standard Dev.	Min	Max
Market Value/ sales revenue	3.11	1.87	.81	10.25
R&D/ sales revenue	11.26	$2.20	5.20	147.77
Firm Growth	10.26%	13.41%	-6.84%	59.46%
Free Cash Flow/ sales revenue	109.07	49.36	30.93	257.56

Market Share	3.66%	6.59%	0.70%	24.70%
Risk	$23.42	$6.04	$10.47	$37.42

Regression Results, Not Corrected for Heteroskedasticity			
Variable name	Original Model	No Firm Growth	No Market Share
Constant	33.79*** (2.87)	28.23*** (3.28)	28.23*** (3.28)
Normalized Research and Development	.279*** (3.87)	.315*** (4.05)	.287*** (4.05)
Firm Growth	.259 (.1.36)		.288 (.1.57)
Normalized Free Cash Flow	.185*** (3.65)	.160*** (3.35)	.179*** (3.60)
Market Share	-.284 (-0.70)	-.407 -1.02	
Risk	-1.349*** (-2.90)	-1.24** (-2.67)	-1.184*** (-2.97)
R-squared	.497	.475	.492
N	48	48	48
Significance level at .10* .05 .01*** t-statistics in parentheses**			

White's Test for Heteroskedasticity			
Variable name	Original Model	No Firm Growth	No Market Share
R-squared	.291	.460	.272
N	48	48	48
R squared * N	13.97	22.08	13.06
Chi squared at .05	5.99	5.99	5.99
Chi squared at .01	9.21	9.21	9.21
Chi squared at .001	13.82	13.82	13.82
If R squared * N is larger than Chi squared it is an indication of heteroskedasticity			

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