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An Analysis on Investment into Research and Development and Its Influence on Profitability in the Medical Device Sector of the Economy

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Abstract

The purpose of this paper is to analyze whether or not investing more funds into research and development will lead to higher profitability, and the analysis will be done by examining the musculoskeletal division of the medical device industry. My research will tie in with production function theory as well as Schumpeter's theory of creative destruction. This paper will also use past research to show what has been done to evaluate the positive relationship between research and development and risk and how this could alter profitability. Through theory and past research an appropriate testable hypothesis will be developed. In order to test the hypothesis, data will be drawn and used in regression analysis as well as descriptive statistics to verify a significant relationship. In order to perform regression analysis an empirical model will be made which will show the dependent variable and how it will be tested against an independent variable as well as control variables. A discussion of the results will then occur as well as mention of future research.

An Analysis on Investment into Research and Development and Its Influence on Profitability in the Medical Device Sector of the Economy

Jake Nord

I. Introduction

“Fundamental to capitalistic growth is innovation.” This quote is from the survey article entitled “Contemporary Capitalism.” (Lazonick, 2008) Innovation is the process that generates goods and services that are of better quality and lower prices than their predecessors. Therefore, if a firm explores innovation, then they will inevitably lead themselves to an efficient allocation of society’s resources and growth within the firm will occur. Innovation does not only improve a firm’s profitability but also the quality of life for all consumers in the economy. There is no greater need for innovation than in the medical sector of the economy. With an aging population, and an estimated life expectancy of now 78, consumers in America are constantly demanding new hip prostheses, shoulder fracture components, and spinal implants. The need for innovation and the diverse investment strategies into research and development in the medical device sector of the economy should allow for the medical device sector to provide a good focus for this paper’s research analysis.

The purpose of this paper is to analyze whether or not investing more funds into research and development will lead to higher profitability, and the analysis will be done by examining the musculoskeletal division of the medical device industry. My research will tie in with production function theory as well as Schumpeter’s theory of creative destruction. This paper will also use past research to show what has been done to evaluate the positive relationship between research and development and risk and how this could alter profitability. Through theory and past research an appropriate testable hypothesis will be developed. In order to test the hypothesis, data will be drawn and used in regression analysis as well as descriptive statistics to verify a significant relationship. In order to perform regression analysis an empirical model will be made which will show the dependent variable and how it will be tested against an independent variable as well as control variables. A discussion of the results will then occur as well as mention of future research.

II. Theory

Theoretically, expenditure on research and development should have a significantly positive relationship with the profitability of the firm. As explained by Ikoma (2006), “Even if the production yield gradually decreases with more innovation, simplifying production processes can have a significant impact on profits.” Ikoma’s idea can be shown through past research. According

to Kafouros (2005) a high investment into research and development should have a significantly positive relationship with productivity. A Cobb-Douglass production function as well as Schumpeterian theory also suggests a relationship between productivity and profitability. Finally, past research will show how risk in investing into research and development can affect a firm’s profitability.

Past research has been done in the UK examining 170 firms showing that an increase in research and development expenditure will increase the firm’s productivity, Kafouros (2005). The empirical findings show that there is a positive and significant impact that research and development expenditure has on productivity. There seems to be a higher rate of return on research and development expenditures for sectors that are the net users of innovation. In other words, for sectors of the economy that focus on innovation, their expenditure on research and development will have a more significant impact on their productivity.

The research design used by Kafouros (2005) focused on the Cobb-Douglass production function in its growth rate form. The model contains the standard factors of capital and labor, but also includes the factor of knowledge capital. The purpose for including the factor of knowledge capital is to capture the increases in productivity that come from an increase in technology.

All of the 170 firms were quoted on the UK stock market. The firms chosen for the research come from the manufacturing sector of the UK economy, and information on all firms were found, however some firms were reported as having no investment into research and development and were disregarded. Furthermore, the 170 firms are segregated into two groups; innovating and non-innovating for a deeper evaluation of the data. (Kafouros, 2005)

The paper uses what it calls “R&D intensity” which is the average of R&D expenditure over sales for the year as its main factor in determining profitability. The average R&D intensity for all of the UK manufacturing is 2.1%. In order to calculate productivity, data were collected on employment, capital and output for each firm. Employment was calculated as the firm’s number of employees, capital was measured using total fixed gross assets, and finally total sales were used to measure output. Sales and capital were both divided by employment in

order to get per capita values. (Kafouros 2005)

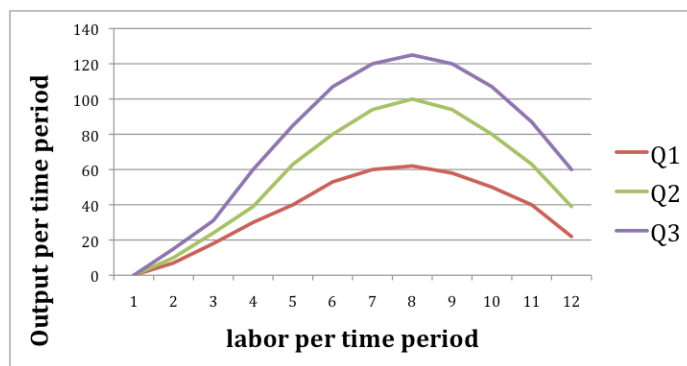
The regression analysis used in this article was ordinary least squares. The article runs three regressions. The dependent variable of each model is productivity growth. The first model included only the capital to labor ratio. The second added R&D intensity to the mix. Finally the labor term was added for the third regression in order to check for constant returns to scale. The same estimates are then repeated in the article with the 10 sector dummy variables in order to check for a consistency over all sectors.

The results show that R&D intensity is significant at the .10 level. The gross rate of return, accounting for constant returns to scale and labor, is .27. In other words, for every additional pound spent on research and development yielded output would increase by £1.27 holding all other things constant. The results found by Kafouros are similar to results found in Japan, the US, and France which were done in other similar research papers. When the sample is split, there is a higher return for innovating firms than non-innovating firms. This shows that being an innovator is an important factor when considering investment into research and development. However, once dummy variables were introduced the variable R&D intensity became insignificant. The dummy variables include time differences and industry differences. The results here show that there is an important role for different sector conditions in allowing for innovation and advancement in productivity. (Kafouros 2005)

Kafouros (2005) shows that there is a significant and positive correlation between research and development expenditure and productivity. The findings here are extremely crucial because if we can show that if the profitability of a firm rises along with productivity of a firm then theoretically research and development expenditure should have a significant and positive relationship with the profitability of the firm. In order to show this relationship I will use Cobb-Douglass Production as well as Schumpeterian theory.

As shown by Howitt (2008), the Cobb-Douglass production function shows that advancement in technology leads to a higher growth in output. The Cobb-Douglass production function is an extension of the typical production function that states that $q = F(K,L)$. Here, the output of a firm is dependent on a function of capital and labor. The Cobb-Douglass production function takes this concept a little bit further and states $F(K,L) = AK\alpha L\beta$. The important thing to notice about this equation is the addition of the "A" variable. "A" is a constant which represents technology or productivity. According to the Cobb-Douglass production function "The larger the value of A, more can be produced for a given level of K and L. (Pindyke, 2009)" By applying this to my research paper we can see that theoretically a larger investment into R&D should result in a greater change in "A", which would cause the company to become more efficient in its production. Technological improvement is shown illustratively in Figure 1.

Figure 1:



The Cobb-Douglass production function shows that if there is advancement in technology, then there will be output growth. The next step is to show the relationship between output growth and profitability growth. If there is an increase in the productivity of a firm, this means that the firm can generate more output for each input, and as shown in figure 1, the curve of the production function will rise. Therefore, there will be a fall in per unit cost for the firm and profits will rise. If this occurs then the firm may become more profitable. Not only could investment in R&D boost production, but it could also create new products. The new products could bring in new profits by themselves, thus leading to a growth in profitability.

Along the lines of new products comes Schumpeterian theory. This theory was developed by Joseph Schumpeter in 1942. Schumpeter argues that "in dealing with capitalism we are dealing with an evolutionary process." He goes on to state that the "main driving force of capitalism is the creation of new goods and new methods of production. (Heertje, 2008)" The theory centers around the idea that when innovation takes place new products are made that cause older products to become obsolete. He calls this process "creative destruction" because the creation of a new product destroys the market for an older product. Schumpeter argues that in order for firms to survive in an industry they must compete for creating new products. Firms do this by investing into research and development. In other words in order for an economy to grow faster the economy must invest more capital and resources into research and development. Schumpeter goes on to argue that the process of creative destruction takes time. Investment into research and development may not have an influence in the economy for a number of years. Interestingly Schumpeter argues that price competition is not the only component of market behavior. Rather, firms compete for producing new advanced products. Therefore, by investing more into research and development a firm has a higher probability of creating that new product, which will give them higher returns, and therefore higher profitability. As shown by past research done by Kaforous (2005) as well as the Cobb-Douglass production function and Schumpeterian theory, as a firm invests more funds into research and development the firm should experience higher profitability.

Theoretically it is true that as firms invest more into research and development they will experience higher profitability. However, investing into research and development is investing into an unforeseeable future. The risk is that there is a possibility of the new product not performing well, not

being desired, or not outperforming other products in the market. Therefore, as a firm invests more into research and development they are taking a gamble. The gamble will theoretically, on average, generate higher profits. However, gambling on R&D will also likely generate greater variability in profits compared to firms that do not take significant gambles on R&D.

Machina and Rothschild (2008) state that, "The phenomenon of risk is one of the key determining factors in the formation of investment decisions." Furthermore, the article states that there can be two types of investors in an economy, a risk adverse person and a risk lover. In relation to this paper, companies that invest little into research and development may be more risk adverse than those that invest more funds into research and development. The incentive for a risk loving investor should be that the possible gains of his investment should be more than the possible losses. Therefore, even with the possibility of the investment into research and development going sour, the possible gains should outweigh the possible losses. As firms invest more into research and development we should see a higher volatility of returns, however the overall correlation taking into account this volatility, should still be positive between investment into research and development and profitability. This leads me to state my formal hypotheses:

Hypothesis I

As more funds are spent on research and development a firm's profitability will increase leading to a higher rate of return on the firm's stock price.

Hypothesis II

As more funds are spent on research and development a firm's profitability will become more volatile causing a firm's rate of return on their stock price to fluctuate more over time.

III. Data and Empirical Model

The data for my empirical model will come from the musculoskeletal division of the medical device industry of the economy. The companies have been gathered from the Cowen and Company Publically Traded Medical Technology Company Database. The data gathered for each company come from Yahoo! Finance and MSN Money. It will be necessary to manipulate the data, and use variables to control for differences between the companies. There are 16 companies in the analysis. A list of these companies can be seen in appendix 1. This paper will use ordinary least squares (OLS) regression analysis as well as descriptive statistics to study the relationship between investment into research and development and profitability.

The reason for using the musculoskeletal division of the medical device sector stems from past research done by Kafourous (2005). The article shows that the sectors of the economy that experience the greatest growth in productivity from research and development expenditure are those companies that are the net users of innovation. In order to derive the best possible results it is necessary to use an industry that focuses on innovation. Medicine is one of those industries. As Americans are living longer, the older generation is continuously looking for new orthopedic devices. The advancing demand causes healthcare to be a hub for technological advancement.

In order to measure the profitability of each firm this paper uses each firms' rate of return on their stock price over the recent recession, which started in December 2007 and ended in June 2009. Since many of the companies' data do not date back to before the most recent economic expansion this analysis is restricted to only focusing on the most recent economic recession, with no expansionary period included. The reason for using stock prices is that the stock price of a firm should reflect investor's perception of the present value of future net earnings for that firm.

In order to measure investment into research and development it is necessary to extrapolate the data from the financial sheets of each company. In order to control for the differing sizes in each company, investment into research and development is taken as a percentage of revenue. Since research and development expenditures usually do not affect the market for 1.5 to 3 years it will be necessary to view the investment into research and development from 2005 to 2007. Other controls are necessary for the OLS regression. A summary of all of the variables for this paper's analysis is listed in Table 1.

Equation for my analysis: $Rate\ of\ return = \beta_1 + \beta_2(R\&D/Revenue) + \beta_3(Growth) + \beta_4(Free\ Cash\ Flow) + \beta_5(Market\ Share) + \beta_6(Size) + \beta_7(External\ Financial\ Dependence) + e$

The control variables seen in the table come from (Salamanca 2010). In his article he describes how a number of variables could affect a firm's decision on how much to invest into research and development. His analysis will give the correct set of tools to control for various factors that could affect investment into research and development.

Firm growth should have a positive relationship with profitability. R&D spending facilitates the success of the firm in the product market, and as a result, R&D spending leads to a higher rate of growth. Therefore, if a firm has been successful in the market in previous years, then they will most likely have better success in their research and development expenditures in the future. This is needed to control for in explaining why some firms may invest more into research and development than others.

Free cash flow is a measurement of all of the available funds in excess of funds needed to pay for all NPV projects. This statistic is taken off of each company's financial statements. According to the article free cash flow should have a negative impact on a firm's profitability because a firm with excess funds may be persuaded to invest into riskier endeavors.

Market share is the percentage of sales a firm has of the total sales in their market. For this dataset each company's revenues are added up and that is the market base. The market share for each company is calculated as the percentage of each company's revenue of the market base. According to the article market share should have a positive relationship with profitability. A firm with higher market share will tend to innovate more, leading to more profitability. Also a company with a higher market share may be more widely known and have their products tested by the public more often than other firm's due to reputation.

The size of a firm is a measurement of how many employees the firm has. According to the article the size of a firm is positively related to firm profitability. A larger firm can take advantage of economies of scale as well as easier access to capital markets and R&D cost spreading.

External financial dependence captures the proportion of a firm's investments that cannot be financed by internal resources. According to the article external financial dependence is a "handicap" that is negatively assessed by the market when firms undertake R&D projects. What the article means by a "handicap" is that the firm may not be able to explore all possible R&D projects because they are being funded by outside sources. Therefore, firms with more external financial dependence may be at a disadvantage.

Labor and capital intensity deal with the amount of labor and capital used in the research and development process. Since financial statements do not reveal this information it is impossible to retrieve these statistics.

All of these control statistics, with the exception of firm growth, will be measured from 2005-2007 in order to stay in line with the investment into research and development statistics. Firm growth will be measured from 2004-2006 in order to account for the growth of the firm in the year prior to the decision to invest into research and development (Salamanca 2010).

IV. Results

The regression results for four models are presented in Table 2. The first model includes only the primary independent variable, R&D / Revenue. Model two includes in the financial controls which are firm growth, free cash flow, and external financial dependence. The third regression includes all variables. The fourth and final regression is a correction for heteroscedasticity.

As shown in Table 2, there is not a lot of significance in these regressions, which does not give much support for the first hypothesis, which claims a direct relationship between R&D expenditures and the changes in stock price. However, a White's test was ran which showed that there was heteroscedasticity, which gives some support for the second hypothesis. Heteroscedasticity explains that as the independent variable changes, the standard deviation of the dependent variable will change as well. In relation to this paper, heteroscedasticity is showing that as investment into R&D grows, the standard deviation of the rate of return of stock prices is growing as well, which is showing that there is a sense of risk in investing more funds into research and development. In other words, heteroscedasticity is explaining that by investing more into research and development the data are experiencing more volatile returns in their stock price. By using descriptive statistics more evidence can be shown for the second hypothesis.

The scatter plot in Figure 2 shows all of the data with relation to their investment into R&D and their rate of return on their stock price over the recession period. In order to perform a descriptive statistical analysis the data will be split into two. The division of the data is shown in the scatter plot by a vertical line. The descriptive statistics will analyze the two hypotheses

by evaluating the statistical differences in means of the rate of returns for the two groups as well as evaluating the statistical difference in each groups' standard deviation of their rate of return.

In order to perform descriptive statistics the data were split into two groups, which are a low investment into R&D group and a high investment into R&D group. Figure two illustrates the division of data through a scatter plot. Here you can visually see evidence for heteroscedasticity in the data.

Figure 2:

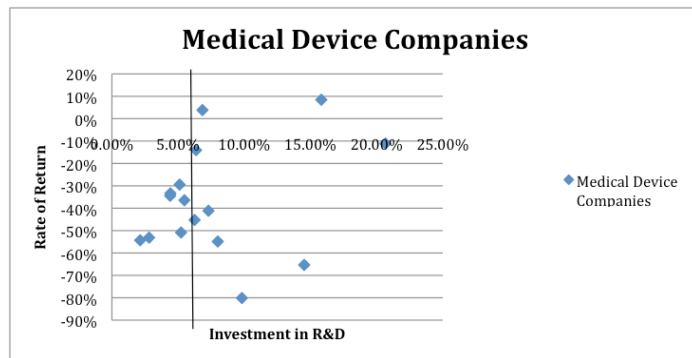


Table 3 shows the firms who have a smaller investment into research and development listed on the left in blue, and the firms who have invested more into research and development listed on the right. The key figures to focus on here are the mean and standard deviation of the two groups. As expected, the mean rate of return on stock price for the higher invested into R&D firms is higher than the lower invested R&D firms, which shows evidence for the first hypothesis. Also, the standard deviation is higher for the higher invested R&D firms than the lower invested R&D firms, which shows evidence for the second hypothesis. By using descriptive analysis, this paper will test if the means and standard deviations for the two groups are statistically different.

The two sample test of means with σ unknown and unequal failed to reject the null hypothesis; therefore we cannot say that the means for the two groups is statistically different in this analysis. Therefore, due to the regression analysis and the descriptive statistics failing to show support for the first hypothesis we must reject it, and we cannot say that as firms invest more funds into research and development they will experience a higher rate of return on their stock price. These results do not coincide with this paper's theory which was developed through past research done in Kafouros (2005). The theory was that as production improved so would profitability. These results are troublesome. However, with future research and adjustments to this analysis, hopefully future results will be more significant. The results for the two sample test of means with σ unknown and unequal are shown in Table 4.

The difference in standard deviations test rejected the null hypothesis. Therefore, we can say that there is a significant difference in standard deviations for this analysis, and we can accept hypothesis 2, which states that as more funds are spent on research and development a firm's profitability will become more volatile causing a firm's rate of return on their stock price to fluctuate more over time. These results do coincide with

theory stated in Machina (2008). Risk, therefore, does play its role in expenditure on research and development. The analysis for a difference in standard deviations can be shown in Table 5.

More analysis was done on these two groups to understand why some companies spend more on research and development and others spent less. This paper analyzed the differences in the two groups by looking at their control variables, which included firm size, firm growth, free cash flow, market share and external financial dependence. Another variable was included in this analysis, which was the beta coefficient. The beta coefficient is a measure of a firm's stock price volatility.

As shown the firms who spent more on research and development typically have fewer employees, a higher growth rate, less free cash flow, a lower market share, and less external financial dependence. In other words, those who spend more on research and development tend to be smaller and more growth driven. Those who spent less on research and development tend to be more well established and more risk adverse. Those larger, more risk adverse firms who spend less on research and development also tend to have a more stable stock price, which is supported by the beta coefficient. This conclusion is also supported by the results found in the regression analysis as well as the descriptive statistics for the difference in the standard deviation for each group.

V. Conclusion

This paper has shown that as research and development increases for a firm, their rate of return on their stock price does not necessary increase more relative to other firms. However, this paper has shown that those who spend more on research and development do experience more volatile returns. Therefore, the first hypothesis is rejected and the second hypothesis is not rejected in the context of this paper. In relation to other findings, Kafouros's (2005) findings that a higher investment into research and development will generate greater productivity is neither supported nor rejected by the findings presented here due to the differences in foci in the two papers. The focus of Kafouros (2005) was productivity, and the focus in this paper was profitability. Schumpeterian theory and the Cobb-Douglass production are neither supported nor rejected for the same purposes. However, Machine and Rothschild (2008) are supported by the findings of this paper, which show that more investment into research and development lead to a greater deal of risk.

In order to improve the analysis, future research could evaluate the problem addressed in this paper differently. Future research could involve a larger database, a different sector of the economy, or even use a different time period. By using a larger database outliers' effect on the database could be weakened. Also with more data the strength of the regression analysis would grow. In order to get a larger database future research could either analyze a different sector of the economy, or it could include more data in this sector of the economy. For example, the data in this database came strictly from the musculoskeletal medical device sector; however the database could expand itself to include other medical device makers outside of the musculoskeletal sector. Finally, future research could examine a difference time period. Seeing that the time

period used was during a recession, there could have been more extreme volatility than we would typically expect. Also during a recession most companies are acquiring negative returns and the firms are doing damage control. However, it would be interesting to see an analysis of an expansionary period where innovation is encouraged more.

So, what do the results mean? Should companies spend more or less on research and development? The paper has given us the answer that it depends. If a company is smaller and more growth oriented, it could be beneficial to take the risk for higher returns, however if a company is more well established and is in a good position with more market share, it could be more beneficial to spend less of their revenue on research and development.

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Table 1: Variable Definitions and Expected Signs

Variable	Definition	Expected sign
<i>Dependent Variable:</i>		
Profitability	Change in stock price over the recession (Dec, 1 2007 – Jun, 1 2009)	
<i>Explanatory variables:</i>		
Main Focus		
R&D / Revenue	Amount in dollars spent in R&D / Revenue	+
Control Variables		
Growth	Change in revenue over the time period 2004-2006	+
Free Cash Flow	Leveraged free cash flow as stated in financial statements	-
Market Share	Revenue of individual firm over total	+
Size	Number of Employees	+
External Financial Dependence	External financials as stated in financial statements	-
Labor Intensity	Labor used in research and development	-
Capital Intensity	Capital used in research and development	-

Table 2: R&D regression for Medical device Firms

Variables	Model 1	Model 2	Model 3	Model 4
Constant	- .474** (-4.198)	- .489** (-3.225)	- .382 (-1.501)	- .578** (-3.981)
R&D / Revenue	1.360 (1.110)	1.452 (.772)	.502 (.191)	3.146 (1.303)
Firm Growth	-	-3.17E-5 (-.016)	.001 (.323)	-.001 (-.479)
Free Cash Flow	-	-9.37E-12 (-.053)	2.43E-10 (.230)	9.407E-11 (.000)
EFD	-	-1.47E-10 (.284)	-1.92E-10 (-.207)	3.570E-10 (.000)
Market Share	-	-	.021 (.313)	-.010 (-.234)
Firm Size	-	-	-6.37E-5 (-.597)	9.625E-6 (.167)
R ²	.015	-.244	-.460	-.210
N	16	16	16	16

Reject Null Hypothesis if t-stat ≥ 1.753 (.05)

Sig level at .05* .01**

Table 3: Two Group Data Set with Mean and Standard Deviation Analysis

Low R&D expenditure	Investment into R&D	Rate of Return	High R&D expenditure	Investment into R&D	Rate of Return
SNN	4.4%	-34%	ANIK	14.53	-65%
SYK	6.25%	-45%	EXAC	6.36	-14%
ZMH	5.12%	-29%	NUVA	20.67	-11%
IART	5.48%	-36%	OFIX	8.00	-55%
RTIX	2.14%	-54%	VITA	15.82	8%
OSTE	5.23%	-51%	WMGI	7.30	-41%
CNMD	4.42%	-33%	ARTC	9.82	-80%
KCI	2.81%	-53%	SYNO	6.84	4%
Mean	4.48	-42%	Mean	11.17	-32%
σ	1.38	10	σ	5.23	33

Table 4: Two Sample Test of Means - Population Unknown and Unequal

$$H_0 : \mu ROR_1 = \mu ROR_2$$

$$H_a : \mu ROR_1 \neq \mu ROR_2$$

$$t_c = (\bar{X}_1 - \bar{X}_2) / (Sx_1 - x_2)$$

Degrees of freedom = 8.27

Reject if $t > 1.86$

$$t_c = .82$$

We do not reject the null hypothesis

Table 5: Difference in Standard Deviations

$$H_0 : \sigma ROR_1 = \sigma ROR_2$$

$$H_a : \sigma ROR_1 \neq \sigma ROR_2$$

$$F_c = S^2_1 / S^2_2$$

Degrees of Freedom = 7,7

Reject H_0 if $F_c > 3.787$

$$F_c = 10.82$$

We reject the null hypothesis

Table 6: Analysis of Low R&D Expenditure Group and High R&D Expenditure Group

	Firm size	Firm growth	Free cash flow	Market share	External financial dependence	Beta Coefficient
Low average	6,353	25%	\$441,000,000	12%	\$112,000,000	.98
High average	743	40%	\$4,710,000	0.90%	\$31,890,000	1.09

