Capital Investment as a Predictor of Revenue Growth in the Materials and Information Technology Sectors

_____

A THESIS

Presented to

The Faculty of the Department of Economics and Business

The Colorado College

In Partial Fulfillment of the Requirements for the Degree

Bachelor of Arts

By

Thomas C. Keene Jr.

February 2017

Capital Investment as a Predictor of Revenue Growth in the Materials and Information Technology Sectors

Thomas C. Keene Jr.

February 2017

Economics

Abstract

Research about drivers of revenue growth or other firm-specific metrics has been studied, but no research has focused on the impact of capital investment as the primary driver of revenue growth. In this paper, we test the hypothesis, "capital investment positively affects revenue growth, and affects young sectors to a greater extent than mature sectors." We use cross sectional time series GLS for both sectors and find evidence to partially support the claim**.** We find that there is positive correlation between capital investment and revenue growth for the S&P 500 Materials sector whereas capital investment is not a significant predictor of revenue growth for the S&P 500 Information Technology sector.

KEYWORDS: capital investment, growth
JEL CODES: G31, O16, O41

ACKNOWLEDGEMENTS

First, I would like to express my sincere gratitude to my thesis advisor Professor Jim Parco of the Economics Department at Colorado College. He consistently allowed this paper to be my own work, but provided guidance whenever I thought I needed it. I could not have completed this thesis without knowing that his door was always open.

I would also like to thank my parents for providing me with support during my tenure as a student at Colorado College and the encouragement they continuously offered me. This accomplishment would not have been possible without them.

ON MY HONOR, I HAVE NEITHER GIVEN NOR RECEIVED UNAUTHORIZED AID ON THIS THESIS.

Signature

TABLE OF CONTENTS

ABSTRACT i

ACKNOWLEDGEMENTS ii

1 INTRODUCTION 1

2 THEORY 2

CAPITAL INVESTMENT 2

2.1 *Why Capital Investment Matters* 2

2.2 *Economic Thoughts on Capital Investment* 6

2.3 *Other Benefits of Capital Investment* 8

2.4 *Capital Investment as a Proxy for Global Competitiveness* 10

2.5 *Causes of Investment Stagnation* 11

2.6 *Savings* 15

3 MODEL 15

4 DATA 19

5 METHOD 19

6 RESULTS 21

7 CONCLUSION 24

8 WORKS CITED 28

9 APPENDIX A. 32

1. INTRODUCTION

The Information Technology (IT) sector of the Standard and Poor's (S&P 500) is dynamic and fast-growing. Although still in a young stage, it could start to enter its maturity phase soon. The S&P 500 Materials sector, however, is made up of mature industries, with storied histories in the United States. The differences between these two sectors make it unclear if growth initiatives should be the same or different. Due to this, companies need to review their strategies on how to keep growing to compete and create value. Scholars have argued that a company's performance is determined either by the industry attractiveness or by the firm's distinctive resources and capabilities (Porter, 1980; Luo, 1998). These factors also affect strategic decisions that involve investment. This ongoing debate, however, has not been solved and it may never be solved because of the ever-morphing state of the economy, so it is hard to definitively determine what factor or factors play the most into a company's success.

There are two primary ways for a company to grow endogenously: (1) increase the number of inputs that are a part of the production process; (2) find a way for each input to lead to more output, both of which capital investment plays a vital role in (De Long & Summers, 1990). Investment in new equipment is one of the primary means by which growth flows through an economy. Without capital investment, existing equipment becomes outdated and less efficient, and equipment with new technology is not able to diffuse through the national economy. In this paper, we examine many different considerations of capital investment, such as why capital investment matters, different economic theories on capital investment, the benefits of capital investment, trends and analysis of historical capital investment, and some of the causes of investment stagnation.

This thesis examines the role that capital investment plays in revenue growth across the Materials and Information Technology sectors of the S&P 500.

2. THEORY

While there are many drivers of growth in a business within the macro and the micro level, capital investment is necessary for companies to realize sustained revenue growth. Strategic capital investment has a larger impact on younger sectors than mature sectors.[1]

2.1 Why Capital Investment Matters

Innovation is embodied in new plant and equipment, and capital investment is the primary means of diffusing this innovation throughout the economy (Solow, 1957). This diffusion of innovation allows an economy, and the sectors that have adapted new capital, to grow. Some examples from the Bureau of Economic Analysis include information processing equipment and software, industrial equipment, transportation equipment, and agricultural machinery, and service industry machinery ("Current-Cost Net Stock of Private Fixed Assets," 2016). Innovation of new technologies allows for an improved quality of life where that technology is disseminated (Muroyama, 1988). If a crisis occurs, technology allows for the possibility to shift reliance from one input to another. For example, Japan pivoted away from a strong dependence on oil during the oil crisis to more energy-efficient manufacturing processes, which allowed their economy to continue to grow at a steady pace (Vivoda, 2014). Industries that adapted to the energy price hike in

[1] The average age of companies in a sector to be defined as a "young" sector must be under 50 years. It must be over 50 years to be defined as "mature."

the 1970s by adopting more energy-efficient technology, such as steel, also saw the most growth during this time (Japan Center for Economic Research, 2012).

Other economists have examined the role of capital expenditures versus research and development (R&D) outlays on the uncertainty of future earnings. The findings concluded that R&D outlays were three to four times more likely to yield cash flow uncertainty compared to capital expenditures, meaning that capital expenditures are a more reliable source of future earnings predictability (Kothari et al., 2001). It is important to note, however, that the tradeoff between weighting each of these expenses differently is uncertain. Some industries, such as biopharmaceuticals, are heavily dependent on R&D expenses and weighting their investment expenses more towards new capital could prove fatal, because they would not have the monetary capacity to develop new products (Grabowski & Vernon, 1998). In fact, they showed that a "decline in new drug introductions" occurred when there was "stagnant growth in R&D expenditures" (p. 201).

Capital investment in the form of replacement or repair of assets, instead of technological advancements, is different because it "involves the displacement or scrapping of some existing capital asset" (Merrett, 1965, p. 153). As opposed to innovation investing, this type of investment also means that the new capital that is purchased will perform the same functions as existing capital, so it does not add as much value as innovation-focused capital investment. There are multiple reasons why a company would engage in this type of capital investment instead of innovation investing, and it is often tied to a life-cycle management approach. This means that companies take into account the usable life of an asset, such as a dam, a machine, or a building, and plan a replacement approach around this life-cycle. The goal of this approach is to make sure that assets are

replaced in an optimal manner, such that downtime of that asset is minimal (Killmier, 1990). Investing in repairing or maintaining an asset is "linked to the organization's product delivery… because failure to invest can result in financial harm to the organization and real or perceived harm to its capacity to perform" (National Research Council et al, 2012, p. 56). Therefore, companies have an incentive to keep their assets operating and productive so that their revenue and profitability are not negatively impacted. Lastly, a company may also replace or modify existing assets in order to meet regulatory requirements set by both the federal and state governments. Regulations require companies to make critical decisions around investment. Consider the paper industry, which is included in the Materials sector. Making paper is complicated, capital-intensive, and requires multiple, different processes. An excerpt from a study conducted by Gray & Shadbegian (1998, p. 238) describes the process:

> *"Paper-making begins with a fiber source such as trees, wood chips, recycled cardboard, or waste paper. Plants beginning with raw wood use a variety of pulping processes (mechanical, chemical, or a combination) to separate out the wood fibers. The resulting mixture of fiber and water is either deposited onto a rapidly-moving wire mesh (the fourdrinier process), or layered onto rotating drums (the cylinder process) before passing through a series of dryers to remove water and create a continuous sheet of paper."*

Each of these processes can have different environmental consequences that can be subject to regulation. If regulations surrounding chemical usage, chlorine bleaching (used for white paper), or a number of other inputs in the production process change, then paper companies will have to invest in modifications or replacement of existing equipment. New regulations

could significantly affect older plants, since they may have older, less environmentally friendly equipment.

A study showed that focusing on improving direct labor productivity creates a short-term mindset for managers (Skinner, 1986). Grant (1991) showed that focusing on the capital investment and capabilities of the firm can create competitive advantages that have a more-long term increase in productivity. These competitive advantages lead to productivity and revenue growth because competitors are not easily able to replicate the use of their assets. Referring to the earlier description of how regulations may affect capital expenditures, if a company undertakes voluntary capital expenditures in a highly regulated environment, they can create a competitive advantage because this new capital may provide them with new capabilities or discourage new entrants (Wirth et al., 2013). Granted, this is not always the case and is subject to a lag between the announcement of capital expenditures and the approval of them, due to regulations.

Additionally, firms that have large cash reserves or accumulating cash balances for capital expenditures can sustain their competitive advantages over time. In fact, a company's competitive advantage hinges on its capital and the time at which it adopts new capital (Dierickx & Cool, 1989). This idea is the baseline of Michael Porter's Five Forces, a widely accepted and utilized framework on how to shape a company's strategic pathway to realize competitive advantages (Porter, 1980).

2.2 Different Economic Thoughts on Capital Investment

Alternative schools of economic thought argue that capital investment plays a different role in economic growth. The following provides a summary of neoclassical, neo-Keynesian, and innovation economics.

2.2.1 *Neoclassical*: The basis of neoclassical economics argues that sustained growth is only possible through the accumulation of capital and technological progress ("Economics - Major Theories", 2008). Accumulation of capital is determined by investment, which is in turn determined by savings at full employment. Two of the major inputs of the Solow-Swan model of production, which is typically employed by neoclassical economists, include labor and capital. Therefore, the more capital investment that a company has, the more it should grow. Robert Solow did, however, model technological change as an exogenous variable, meaning that it is outside the realm of economic inquiry for neoclassical economists (Solow, 1956). This school of thought presumes that investment in physical and human capital are the only factors that drive growth through a company and an economy.

2.2.2 *Neo-Keynesian:* Neo-Keynesian economists subscribe to the notion that investment is not what drives growth. Instead, they believe that the investment by a firm is a function of the "firm's expected stock of money, the expected marginal productivity of capital, and the expected rate of inflation" (Fujino, pg. 1). Investment is viewed as part of aggregate demand, which they argue is what drives the economy. They also assert that increased spending in the economy drives investment in some cases (Bluestone & Harrison, 2000).

2.2.3 *Innovation Economics:* Innovation economics offers a newer theory that capital investment is able to diffuse innovation and technological change throughout an economy (Atkinson & Ezell, 2012). Rather than invest in new grain silos, or other established assets, developed countries have sustained growth due to the introduction of new technologies via capital investment (Rosenburg, 2004; "Knowledge-based Capital Synthesis," 2013). For example, think of the power generation industry, which is changing daily to become more efficient and cost effective. Coal power plants are retiring generating capacity at record numbers and are being replaced by more efficient and more environmentally friendly alternatives. Without capital investment and innovation in the production of natural gas, the energy industry would remain less efficient and more costly Capital expenditures in new production technology has diffused innovation in this sector rapidly (Figures 2.1 and 2.2).

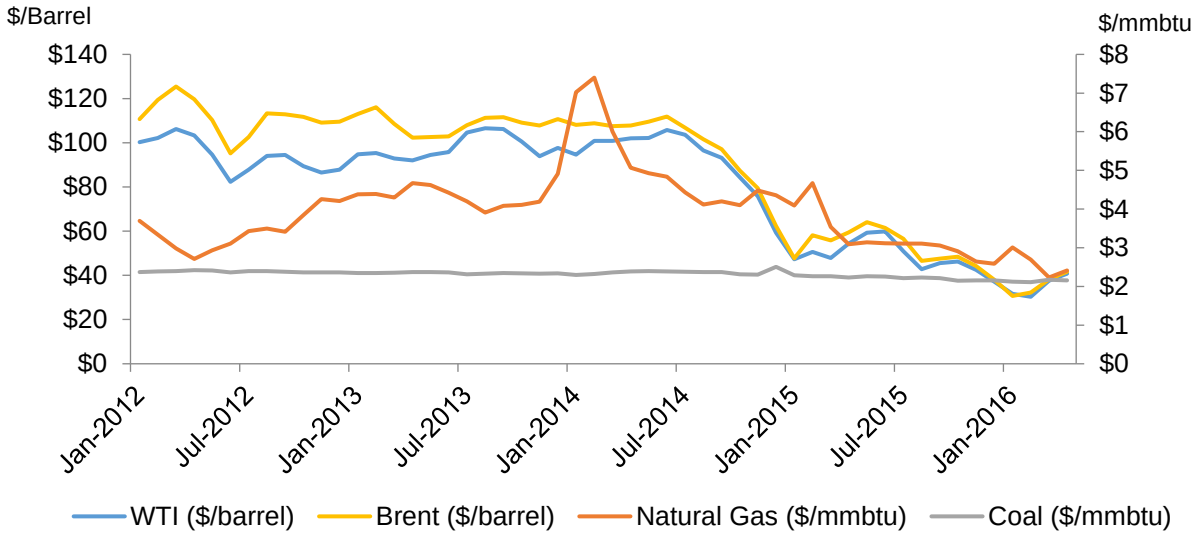

Figure 2.1. Fuel Prices from 2012-Present

Source: Energy Information Administration: Electric Power Annual 2016

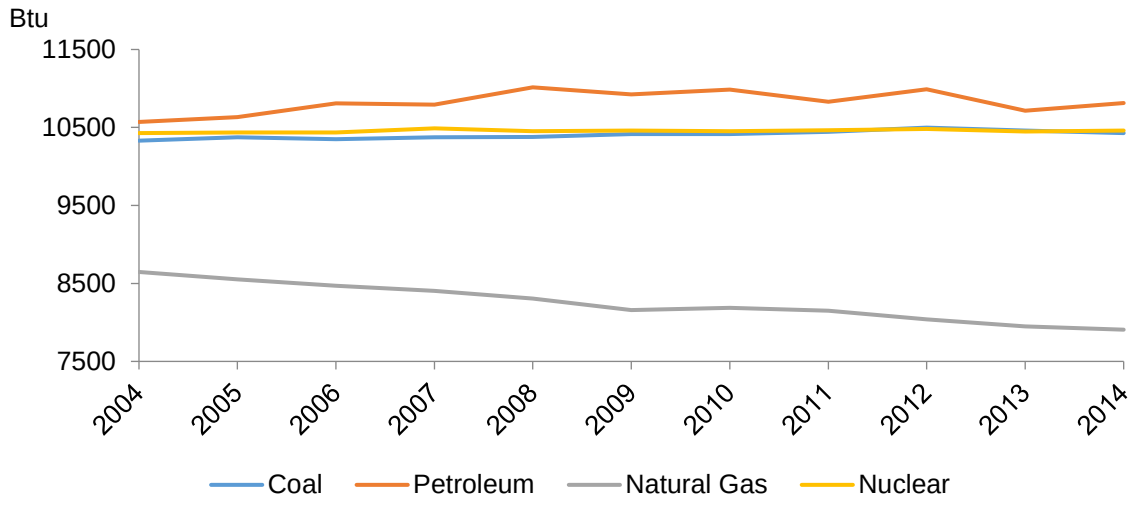

Figure 2.2. Heat Rate of Fuel Sources from 2004-2014.

Source: Energy Information Administration 2016 – Average Cost of Fossil Fuels for Electricity Generation for All Sectors, Monthly

Prices and heat rates for natural gas have decreased over time due to innovation within the industry.[2] As we continue to see innovation in this industry, we will begin to see expanded use of renewables in generation, which will be even more cost effective and environmentally friendly. By 2040, power generation from renewables in the United States will be around 33%, the same that coal and natural gas are today ("World Energy Outlook 2014 Factsheet, 2014).

2.3 Other Benefits of Capital Investment

Capital investment can come in the form of property or equipment. This means that it can be used to acquire new land, improve existing structures, buy new machinery, improve information technology infrastructure, etc. The benefits of capital investment come in three forms: firm benefit, spillover benefit, and economy-wide benefit. Firm

[2] Heat rates affect the marginal cost of production for power generation.

benefits are the benefits that the company which invests in the new capital receives. There are many that depend on the type and function of the capital that is acquired. If it is property, the firm benefits may include expanding into a new market. If investment is in machinery or equipment, firm benefits may include efficiency-improving technology, expanding current capacity, or replacing current capital among other potential benefits.

Spillover benefits, sometimes referred to as positive externalities, are defined as benefits that a third party receives from the actions of another firm. In a business setting, an example would be a wind-turbine company that incurs significant capital expenditure costs for the expansion of its turbine fleet, because local businesses that use wind energy for power generation could market themselves as having a lower carbon footprint even though they incurred none of the costs. A study by Bart van Ark (2002) found that economy-wide benefits from capital investment in new equipment are larger than the firm receives.

If we step even further back, the economy also benefits from capital investment. For example, if a company invests in new property to build a new manufacturing plant, then jobs are created. If an energy company expands its ability to generate power, or invests in new capabilities for producing power, then energy prices will fall. This is also a spillover benefit, just on a larger scale, meaning that there is still a difference between the social and private returns on investment (Barbier, 2005).

It's also important to note that not all capital investment returns benefits in the same magnitude. Investment in equipment affects growth about four times greater than capital investment in non-equipment (Sala-I-Martin, 2002). Firms, however, may be dissatisfied with the fact that they are unable to capture all the benefits of investment, which could lead

to underinvestment. To incentivize investment, governments have implemented investment tax credits and other incentives for investment. Following the previous example, the US government has implemented investment tax credits to incentivize companies to put their capital to use and proliferate renewable energy power generation capabilities ("Business Energy Investment Tax Credit (ITC)", 2009).

2.4 Capital Investment is a Proxy for Global Competitiveness

By investing in capital, a company is investing in long-term growth and competitiveness. Some believe that managers in the US focus on the short-term, thereby underinvesting, and contributing to the United States' competitive decline (Porter, Rivkin, & Canter, 2013). CEOs face a myriad of market pressures that may cause them to focus on short-term results, instead of sustained competitive advantages, especially since the recession of 2008. Due to the market's incessant demand for growth quarter over quarter, "executives underinvest in long-term growth and buy back stock" (Martin, 2015). Short-termism is a problem and for the US to increase its global competitiveness, of which it is currently ranked third overall, eighteenth in market efficiency, and fourth in innovation, it must invest in long-term growth ("Global Competitiveness Report 2015-2016", 2016). It is worth noting that in 2006, the US was ranked first overall, second in market efficiency, and second in innovation (Global Competitiveness Report 2006-2007", 2007). Capital investment has played a role in this competitive decline.

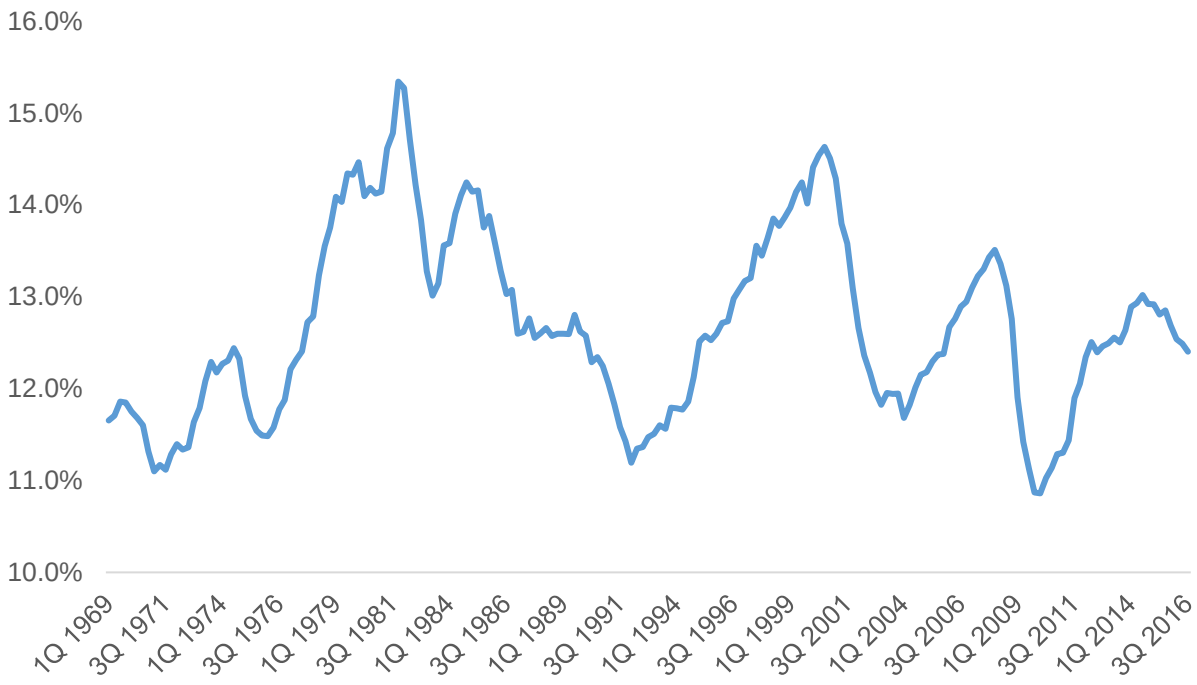

Figure 2.3. Fixed Capital Investment as a Percentage of U.S. GDP

Source: U.S. Bureau of Economic Analysis

Figure 2.3 shows that the US is currently investing at 12% of US GDP, down from 15% in 1981 (National Accounts (NIPA) – Saving and Investment, 2016; National Accounts (NIPA) – Gross Domestic Product and Income, 2016). The chart above is shown in percentages to control for the change in dollar value over time. This chart shows that U.S. nonresidential business investment is shrinking in relative size to the U.S. economy.

2.5 The Causes of Investment Stagnation

Some earlier twentieth-century economists, viewed economic fluctuations as a sign of economic progress (Samuelson & Stiglitz, 1966). The primary indicators of economic progress were "(a) inventions, (b) the discovery and development of new territory and new resources, and (c) the growth of population" (Hanse, 1939, pg. 3). These parameters were applied in the late-nineteenth and early-twentieth centuries, during which investment

opportunities were attractive and plentiful. They did not consider what happens when an economy reaches full employment of available resources, which can lead to secular stagnation, defined as recessions and depressions "which feed on themselves and leave a hard and seemingly immovable core of unemployment" (Hanes, 1939). This theory also argues that demand slows due to improved labor skills and major booms in the economy from major technological change will not happen anymore. Examples of one of these major changes would be the steam engine or the internet. Prior to their introduction and adoption, many people could not imagine the daily impact of these inventions.

Figure 2.4 shows that private nonresidential fixed investment -- measured by spending by private businesses, nonprofit institutions, and households on fixed assets, such as structures, equipment and software – decreases drastically during recessions. If consumers stop spending, so that they can make it out of a recession whole, then companies stop generating revenue. More importantly, they stop generating recurring and predictable revenue, which is crucial for strategic capital planning. If companies stop generating revenue, then their cash flow is impacted, meaning that they do not have earning that they can reinvest into new property plant and equipment. Therefore, we see decreases in investment.

The Materials and IT sectors are not immune to the investment pitfalls of recessions. Figure 2.5 shows a sharp decrease in capital expenditures during rough times for each of these sectors, and they largely follow the same pattern, although Materials is

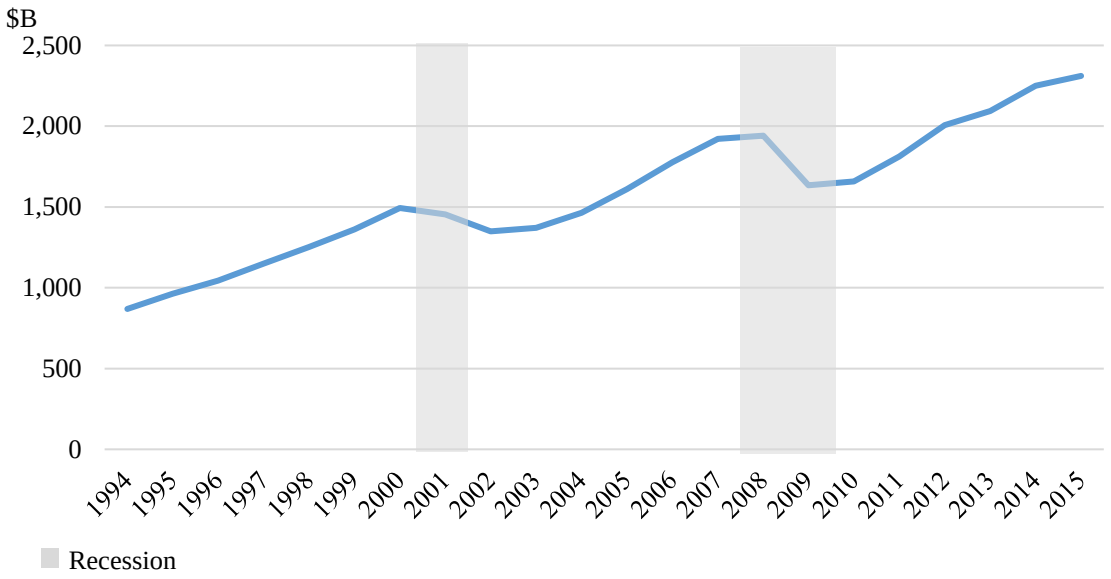

Figure 2.4. U.S. Private Nonresidential Fixed Investment
Source: Federal Reserve Economic Data

less volatile. This is because companies within the Materials sector are already asset-heavy, so they (1) need to continue capital expenditures to maintain their heavy asset-base; (2) have more predictable revenue since they are not as consumer-focused as they are business-to-business focused. Consider International Paper, a paper packaging company that is included in the Materials sector. Even during a recession, businesses need to purchase their products. Additionally, their product is negotiated on a contract-basis, meaning that they know the influx of cash they will receive from their customers over the contract period. EBay, on the other hand, is a company within the IT sector, where their business is generated from customers who bid on individual items. If people have less money in their pockets to use on non-essential products and services, then they will opt to save that money or redirect it to essential uses.

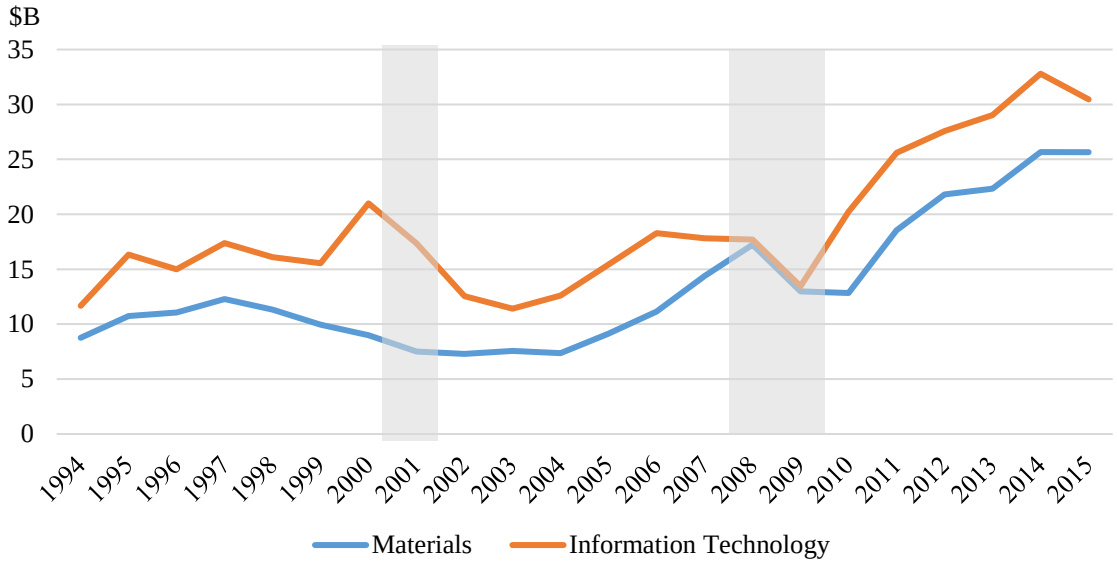

Figure 2.5. Capital Expenditures: Materials and Information Technology Sectors

There may also be financial reasons for companies not to invest in additional capital. Depending on the accumulated capital and depreciation associated with that, asset-heavy companies may not have the credit facilities, cash generation, or profit opportunities to justify additional expenditures. Additionally, it is hard to forecast US business fixed investment spending (Rapach & Wohar, 2007). This is because modelling relies on expectations, but expectations are not always accurate. If we look on a micro-level, companies also have difficulty meeting their models. This is why whole departments exist to track the progress of reaching the outputs of the model, and why they are constantly revised as well.

2.6 Savings

Keynes (1936) asserted that savings and investment are correlated. Figure 2.6 shows that net savings and net investment trace each other. The more that a company or a person saves, the more they should also have to invest. The company has the ability to

invest directly in new equipment, structures, or another asset. The person, however, deposits their money into the bank, which can be loaned to companies so that they can invest in capital as well. By examining the relationship between net savings and net investment, we determine that there are two ways for a company to invest (1) save money (2) borrow money. This is a simple concept, but it is mutually exclusive and collectively exhaustive.

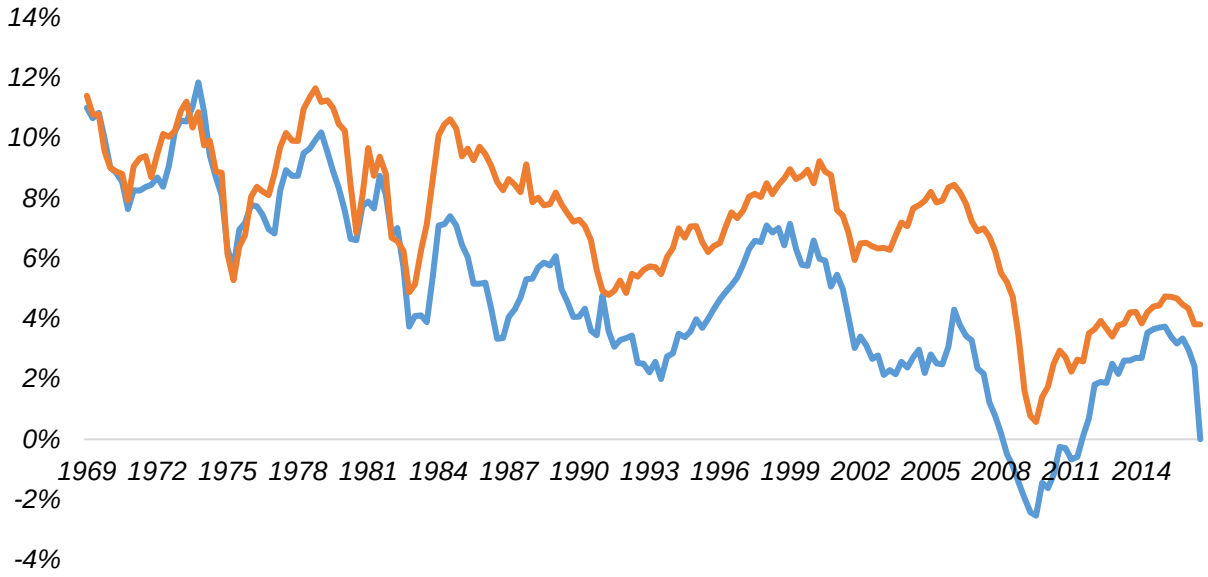

Figure 2.6. Net Savings and Net Investment as a Percentage of GDP

3. MODEL

To observe and understand the effect of capital expenditures and other factors on revenue, we set up a panel data series and used a feasible GLS model to analyze the differences across the Materials and Information Technology sectors of the S&P 500.

$$RevenueGrowth_{i,t} = \beta_0 + \beta_1 CapitalExpenditures_{i,t-1} + \beta_2 GrossProfitMargin_{i,t} + \beta_3 AGE_{i,t} + \beta_4 Population_t + \beta_5 GDPPerCapita_t + \beta_6 RegulatoryEnvironment + error_{it} \quad (3.1)$$

We choose revenue growth because we want to see the effects of capital investment in period 't-1' on revenue in period 't.' As our dependent variables, we choose Gross Profit Margin (GPM) because it is a proxy for productivity (Novy-Marx, 2013). Therefore, we hypothesize that GPM and revenue growth will have a positive correlation. Previous scholars used other items on the financial statement or ratios for creating a market-based measure of productivity (Sloan, 1996; Chan et al, 2001). Novy-Marx suggests that using gross profit is a better proxy since it scales by "a book-based measure, instead of a market-based measure, [so it] avoids conflating the productivity proxy with book-to-market." We choose age as another independent variable because as an industry ages, "it passes through the different stages of the product life cycle" (Vutova, 2013, p. 35).

We choose capital expenditures, with a period of 't-1', as a dependent variable. Based on the literature on capital investment as a necessary means to grow revenue, we hypothesize that this will have a positive correlation with revenue growth and be the primary explanatory variable. One of the primary assumptions in financial modelling is that revenue growth lags capital expenditures. Instead of lagging revenue, though, we altered the time for capital expenditures so that the other dependent variables would remain in the relevant time-period for revenue.

We use population size as a proxy for the market size for both sectors (Rouvinen, 2006). As the size of a market increases, so should the ability to capture additional wallet share of customers and acquire new customers. We hypothesize that population and revenue growth will have a positive correlation.

Another macroeconomic independent variable is GDP per capita. We include this as an indicator for purchasing power and wealth. Therefore, we hypothesize that GDP per capita and revenue growth have a positive correlation.

Lastly, we use a dummy-variable Reg to represent if a company is headquartered in a favorable regulatory environment. '0' represents that a company is in an unfavorable investment environment, and '1' represents that a company is in a favorable investment environment. The investment environment is determined by which state the company is headquartered in, and is then benchmarked against federal regulations ("FRASE Index, 2016).[3] The FRASE Index rates how federal regulations affect each state's economy. It is different for each state because regulations affect certain businesses or industries differently, and each state has a different mix of industries. A rating of one is the benchmark, with a rating over one meaning that regulations affect a state's economy more significantly than others, and a rating less than one means that regulations have a lesser effect on that state's economy. Therefore, states that have a rating of less than one are assigned a '1' for the dummy variable and states that have a rating of more than one are assigned a '0' for the dummy variable. Table 4.1 summarizes the various hypothesis for the independent variables.

[3] All companies are headquartered in the United States, except for one.

Table 4.1

Summary of Correlation Hypothesis

Variable	Hypothesized Correlation
Capital Expenditures (CapEx)	+
GDP per Capita (GDPPC)	+
Population (Pop)	+
Regulatory Environment (Reg)	-
Age of company (Age)	-
Gross Profit Margin (GPM)	+

The unobserved time-specific and company-specific variations are represented by the e_{it}'s. Table 4.2 summarizes the independent to be included in the empirical section of this thesis.

Table 4.2

List of Independent Variables

Factor	Variable
Macroeconomic	Pop
	GDPPC
Regulatory	Reg (dummy)
Company-specific	RevG
	CapEx
	Age
	GPM

4. DATA

We received most of our data from YCharts.com, a popular financial data research platform. After receiving information on revenue, capital expenditures, and gross profit margin, we cross referenced this data with available information on Yahoo Finance and the 10-K forms for randomly selected companies from each sector to check for accuracy. We received annual data from 2000 to 2015 for 25 companies within the Materials sector and 65 companies within the Information Technology sector. We decided to focus on companies whose fiscal year ends on December 31st for consistency across financial data, narrowing our data to 22 companies within the Materials sector and 25 companies within the Information Technology Sector. The companies included in this paper can be found in Appendix A.

We received data on the age of each company by visiting each company's website. We received data on GDP from the Bureau of Economic Analysis and used billions of chained 2009 dollars in billions to account for inflation. Historical population was gathered from the United States Census Bureau.

5. METHOD

To observe and understand the effect of capital expenditures and other factors on revenue, we set up a panel data series and use a cross sectional time series feasible GLS model to analyze the differences across the Materials and Information Technology sectors.

Other studies have also examine effects of capital investment and predictors for revenue growth for other industries (Chadhuri et al., 2010; Vutova,, 2013). We followed similar methodologies to determine our results. We used a GLS model to account for the

differences in variances for different companies and industries. We also transformed capital expenditures, population, GDP per capita to address for heteroscedasticity by taking the natural log of that variable. Transforming nominal variables, such as age, gross profit margin, and regulatory environment was not necessary. Before we settled on using a GLS model, however, we tested normal OLS assumptions to confirm that they did not hold true.

We performed a White Test on the estimates to find that the data is highly heteroskedastic. So, we use the cross-sectional time series feasible GLS model for our data.

We realized that there are possible omitted variables. We have not analyzed some of the characteristics that have been posited to impact revenue growth for each of the sectors we examined: pricing strategy, competitive concentration, market penetration, etc. (Vutova, 2013, p. 75). However, we assume that the variables included are sufficient proxy for all of the characteristics mentioned above. We would like to include those variables in our model, but due to the lack of data, we choose to omit those from our analysis.

The Gauss-Markov assumptions do not hold. So, we did not use OLS, instead we choose feasible GLS model to fit panel data for our analysis assuming heteroscedasticity but no autocorrelation, since we explicitly modeled that with dummy variables for each company across yearly time periods. We performed regressions on both the Materials and Information Technology sectors of the S&P 500 and compared the beta coefficients for revenue growth.

The paper's findings are also robust to a variety of sensitivity checks. These include a control for cross-sector variation in capital expenditure levels, cross-sectional variation in growth, and an exclusion of all firms that report zero capital expenditures.

6. RESULTS

We now discuss the results for each sector, follow by a summary of results for all sectors. The results for the Materials sector are shown in Table 6.1. For this sector, macroeconomic and company-specific are jointly significant.

Only four variables are significant in our model: CapEx, Age, Pop, and GDPPC. As anticipated, the coefficients for CapEx, Age, and GDPPC are positive. Population, however, has a negative coefficient. This is interesting considering that population is a proxy for market size. If the size of your market increases, then intuitively revenue should increase. It is important to note, however, that we are using companies within the S&P 500, so companies outside of the S&P 500 could be capturing additional demand. This means that the industries within these sectors may be fragmenting or allowing for more companies to enter the market. Nooroozian (2008) suggests that having cultural similarities, a lack of language barriers, access to materials, and local knowledge allows for more entrants into the market. Given that we are examining homogenous companies when it comes to these criteria, we can see how similar companies could enter the market.

GPM and Reg were not significant variables. GPM may not be a significant variable because increased productivity does not always mean revenue growth. This means that productivity may impact other items on the financial statements instead of revenue. Regulatory environment not being a significant indicator of revenue growth may be attributed to the fact that we examined how federal regulations in the United States impact state regulations in the United States. Sood et al. (2008) suggests that regulatory environments, when looking at different countries, can have a significant effect on revenue

growth. Regulations between states do not vary as drastically as regulations between different countries.

Table 6.1

Results from the Materials Sector

Sector	Significant Variable	Coefficients	Standard Error
Materials	CapEx	0.031***	0.011
	GPM	0.131	0.091
	Age	-0.001***	0.000
	Pop	-2.978***	0.619
	GDPPC	2.604***	0.598
	Reg	0.003	0.026

*** *denotes significance at 0.1% significance level*
** *denotes significance at 1% significance level.*
* *denotes significance at 5% significance level.*

The results from the IT sector are shown in Table 6.2. Two of the variables for the IT sector were significant: GPM and Age. GPM has a negative coefficient, which means that a decrease in productivity leads to an increase in revenue. This means that companies may be investing heavily in recurring expenses, which leads to revenue growth. Human capital is one of the factors that drives productivity (Fedderke, 2002). Human capital is also a major investment for information technology companies, who rely on proficient coders and highly skilled employees. Therefore, companies such as Google pay recent graduates over six figures out of college. This could also explain why capital expenditures is not a driver of revenue growth for the IT sector. Human capital, reflected by the increase in salaries year over year, may be an explanatory variable for revenue growth for companies in the IT sector, since these companies do not rely on physical products as much

as they do digital ones. Age has a negative coefficient, which makes sense. As a company grows, especially a young company, revenue growth should slow down.

CapEx, Pop, GDPPC, and Reg all were not significant variables. Population may be negative due to the same reason why it was for the Materials sector. It may also be negative because diminishing revenue growth coincides with a consistently growing population.

Table 6.2

Results from the Information Technology Sector

Sector	Significant Variable	Coefficients	Standard Error
Information	CapEx	0.015	0.044
Technology	GPM	-0.691*	0.354
	Age	-0.006***	0.002
	Pop	-5.837	3.482
	GDPPC	-0.008	3.388
	Reg	0.055	0.164

*** *denotes significance at 0.1% significance level*
** *denotes significance at 1% significance level.*
* *denotes significance at 5% significance level.*

We summarized the results for all the significant variables in Table 6.3 for cross-sector comparisons. The only variable that was significant across industries was Age. Therefore, we find mixed support for the hypothesis that capital investment positively impacts revenue growth. The only hypothesis of the correlation between revenue growth and the independent variables that was true and significant across both models was that Age and revenue growth are positively correlated.

Table 6.3

Significant Variables from the Cross-Sectional Time-Series FGLS Regression

Sector	Significant Variable	Coefficients	Standard Error
Materials	Capital Expenditures	0.031***	0.011
	Age	-0.001***	0.000
	Population	-2.978***	0.619
	GDP Per Capita	2.604***	0.598
Information Technology	Gross Profit Margin	-0.691*	.354
	Age	-0.006***	.002

*** *denotes significance at 0.1% significance level*
** *denotes significance at 1% significance level.*
* *denotes significance at 5% significance level.*

7. CONCLUSION

This thesis examined the role that capital investment plays on revenue growth across the Materials and IT sectors of the S&P 500. The motivation behind this thesis was to determine if companies within each of these sectors should explore new strategic growth initiatives due to the maturity phase of business cycles. We theorized that capital investment is necessary for companies to realize sustained revenue growth, and that capital investment has a larger impact on younger sectors than mature sectors.

There are also a number of reasons why capital investment matters. First, it allows for the diffusion of innovation throughout an economy in the form of new equipment and machinery. It also allows for an improved quality of life in the countries where this new innovation is spread, as evidenced by the proliferation in alternative energy that has gotten much cheaper since its inception. It can also come in other forms other than innovative

advances, such as the replacement or repair of current capital. Capital investment also is an indicator of companies planning for the future, instead of focusing on short-termism as a viable business strategy. It is also a proxy for global competitiveness.

The benefits of capital investment are also realized by other entities other than the company that undertakes the investment. It can also create positive externalities on a small scale, or on an economy-wide scale. Capital investment in different assets also yield greater growth, creating incentives for companies to invest in equipment that directly benefit the company and third parties.

Investment stagnation is an issue that has many causes, such as recessions and depressions. The Materials and IT sectors are also affected by stagnation during those times because companies are cash-strapped during these times so they do not have the luxury of discretionary spending. By this same logic, savings and net investment also closely follow the same pattern.

We modelled our theory using capital expenditures in period 't-1', gross profit margin, age of the company, population, GDP per capita, and the regulatory environment where each company was headquartered as the independent variables. Revenue growth was the dependent variable. Consulting literature and following their modelling methodologies, we used a feasible GLS model to analyze the differences that each of the independent variables had on revenue growth across the Materials and IT sectors.

We collected the data from YCharts and double-checked the data using Yahoo Finance and 10-K forms for randomly selected companies. We used data from 2000-2015

to capture a time period that experienced a recession, and only used the data for companies whose fiscal year ends on December 31st to provide consistency.

Our results did not confirm our theory to its full extent. The quantitative analysis partially supported our qualitative analysis. Capital investment still plays a vital role in the operations of a business, but after examining different sectors, it is clear that it plays a more important role in asset-intensive sectors. It makes a greater impact on sectors that rely on physical capital more than human capital. Therefore, it was significant for the Materials sector, but not for the Information Technology sector. This means that companies within the Materials sector need to plan their capital investment strategically in order to create and sustain revenue growth. We believe that the results for the IT sector did not yield this same conclusion because human capital may be a better indicator for revenue growth, because human capital is a major investment for IT companies that rely on highly skilled employees. Age also had a negative correlation with revenue growth across both sectors. This makes sense, because as companies mature and go further into the business cycle, significant revenue growth is not as sustainable, as we discussed earlier in this paper.

There are also other limitations to this study that could be explored in the future. First, the study focuses on only two of the ten S&P 500 sectors, so there are multiple sectors excluded and many industries excluded as well. The findings for this paper cannot be applied to companies that operate in sectors that share similar characteristics.

Another limitation of this study is that we examined sector-wide data. Future work could be focused on only industries, which could give more conclusive results for those specific industries. We also did not account for competition within each of these sectors,

which would be more quantifiable if we looked at industries instead. This could be an important factor for young industries and mature industries.

Lastly, in the future someone could explore the relationship between human capital and revenue growth for young industries or sectors, since human capital is a big investment for technology-oriented companies.

8. WORKS CITED

Ark, B. V. (2002). Measuring the New Economy: An International Comparative Perspective. *Review of Income and Wealth, 48*(1), 1-14.

Atkinson, R. D., & Ezell, S. J. (2012). Innovation Economics: The Race for Global Advantage. *Yale University Press*.

Barbier, E. (2005). Natural Resources and Economic Development. Cambridge, UK: Cambridge UP. Print.

Bluestone, B., & Harrison, B. (2000). Growing Prosperity: The Battle for Growth with Equity in the Twenty-First Century. *Boston: Houghton Mifflin*.

Chan, L. K., Lakonishok, J., & Sougiannis, T. (2001). The Stock Market Valuation of Research and Development Expenditures. *The Journal of Finance, 56*(6), 2431-2456.

De Long, J. B., & Summers, L.H. (1990) Equipment Investment and Economic Growth. Cambridge, MA: *National Bureau of Economic Research*. Print.

Dierickx, I., & Cool, K. (1989). Asset Stock Accumulation and the Sustainability of Competitive Advantage: Reply. *Management Science*, 35(12), 1504-1511.

Fedderke, J. W. (2002). Technology, Human Capital and Growth. *Royal Economic Society Annual Conference, 71*.

Fujino, S. (1974). A Neo-Keynesian Theory of Inflation and Economic Growth. *Berlin: Springer-Verlag*.

Grabowski, H., & Vernon, J. (2000). "The Determinants of Pharmaceutical Research and Development Expenditures." *Journal of Evolutionary Economics, 10*(1): 201-215.

Grant, R. M. (1991). The Resource-Based Theory of Competitive Advantage: Implications for Strategy Formulation. *California Management Review, 33(*3), 114-135.

Gray, W., & Shadbegian, R. (1997). "Environmental Regulation, Investment Timing, and Technology Choice." The Journal of Industrial Economics 46.2: 235-256.

Hansen, A. (1939). Economic Progress and Declining Population Growth. *The American Economic Review, 29*(1), 1-15.

Keynes, J. M. (1936). The General Theory of Employment, Interest, and Money. *New York: Harcourt, Brace.*

Killmier, A. N., & Schilling, K. E. (1990). Asset Replacement Planning (E. Porter, Ed.). *Urban Water Infrastructure, 180,* 83-90.

Kothari, S. P., Laguerre, T., & Leone, A. (2002). Capitalization versus Expensing: Evidence on the Uncertainty of Future Earnings from Current Investments in PP&E versus R&D. *Review of Accounting Studies, 7*, 355-832.

Luo, Y. (1998). Industry Attractiveness, Firm Competence, and International Investment Performance in a Transitional Economy. *Bulletin of Economic Research, 50*(1), 73-82.

Martin, R. L. (2015). Yes, Short-Termism Really Is a Problem. Retrieved October 20, 2016, from https://hbr.org/2015/10/yes-short-termism-really-is-a-problem

Merrett, A. J. (1965). Investment In Replacement: The Optimal Replacement Method. *Journal of Management Studies, 2*(2), 153-166.

Muroyama, Janet H. (1988). Improving the Quality of Life Through Technology. *Globalization of Technology: International Perspectives*. Washington, DC: National Academy Press. 177-80.

National Research Council, Division on Engineering and Physical Sciences, Board on Infrastructure and the Constructed Environment, and Committee on Predicting Outcomes of Investments in Maintenance and Repair for Federal Facilities (2012). Effective Practices for Investment in Maintenance and Repair. *Predicting Outcomes of Investments in Maintenance and Repair of Federal Facilities*. Washington, D.C.: National Academies. 55-71.

Noroozian, H. (2008). *Competition problems and market entry barriers for Swedish and international actors* (H. Lind, Ed.)

Novy-Marx, R. (2013). The Other Side of Value: The Gross Profitability Premium. *Journal of Financial Economics, 108*(1), 1-28.

Porter, M. E. (1980). *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York: Free Press.

Porter, M. E., Rivkin, J. W., & Canter, R. M. (2013). Competitiveness at a Crossroads. Retrieved October 20, 2016, from http://www.hbs.edu/competitiveness/research/Pages/research-details.aspx?rid=8

Rapach, D. E., & Wohar, M. E. (2007). Forecasting the recent behavior of US business fixed investment spending: an analysis of competing models. *Journal of Forecasting, 26*(1), 33-51.

Rosenburg, N. (2004). Innovation and Economic Growth. Retrieved October 15, 2016, from https://www.oecd.org/cfe/tourism/34267902.pdf

Rouvinen, P. (2006). Diffusion of Digital Mobile Telephony: Are Developing Countries Different? *Telecommunications Policy, 30*(1), 46-63.

Sala-I-Martin, X. X. (2002). 15 Years of New Growth Economics: What Have We Learnt? *SSRN Electronic Journal.*

Samuelson, P. A., & Stiglitz, J. E. (1966). *The Collected scientific papers of Paul A. Samuelson*. Cambridge, MA: M.I.T. Press.

Skinner, W. (1986). The Productivity Paradox. *Journal Management Review*, *75*(9), 41-45.

Sloan, R. G. (1996). Do Stock Prices Fully Reflect Information in Accruals and Cash Flows about Future Earnings? *The Accounting Review, 71*(3), 289- 315.

Solow, R. M. (1956, February). A Contribution to the Theory of Economic Growth. *The Quarterly Journal of Economics*, *70*(1), 65-94.

Solow, R. (1957). Technical Change and the Aggregate Production Function. *The Review of Economics and Statistics, 39*(3), 312-320.

Sood, N., Vries, H. D., Gutierrez, I., Lakdawalla, D. N., & Goldman, D. P. (2008). The Effect Of Regulation On Pharmaceutical Revenues: Experience In Nineteen Countries. *Health Affairs, 28*(1).

Strischek, D. (2003). The Impact of Working Capital Investment on the Value of a Company. *The RMA Journal*, 48-55.

Vivoda, V. (2014). "The Evolution of Energy Security and Energy Policy in Japan." *Energy Security in Japan: Challenges After Fukushima.* Ashgate Publishing Group. 25-33.

Vutova, M. (2013). *Factors for Revenues and Market Share Growth in the Mobile Telecommunications Industry* (F. Richter & W. Smolny, Eds.).

Wirth, C., Chi J., Young, M. (2013). The Economic Impact of Capital Expenditures: Environmental Regulatory Delay as a Source of Competitive Advantage? *Journal of Business Finance & Accounting, 40*(1-2): 115-141.

Websites

Average Cost of Fossil Fuels for Electricity Generation for All Sectors, Monthly. (2016). Retrieved October 15, 2016, from http://www.eia.gov/electricity/data/browser

Average Operating Heat Rate for Selected Energy Sources. (2016). Retrieved October 14, 2016, from http://www.eia.gov/electricity/annual/html/epa_08_01.html

Business Energy Investment Tax Credit (ITC). (2009). Retrieved October 17, 2016, from http://energy.gov/savings/business-energy-investment-tax-credit-itc

Current-Cost Net Stock of Private Fixed Assets; Equipment, Software, and Structures; by Type. (2016). Bureau of Economic Analysis. Retrieved from October 11, 2016, from https://www.bea.gov/National/FAweb/AllFATables.asp

Economics - Major Theories. (n.d.). Retrieved October 12, 2016, from http://science.jrank.org/pages/9055/Economics-Major-Theories.html

Global Competitiveness Report 2006-2007. (2006). Retrieved October 21, 2016, from http://www3.weforum.org/docs/WEF_GlobalCompetitivenessReport_2006-07.pdf

Global Competitiveness Report 2015-2016. (2015). Retrieved October 21, 2016, from http://reports.weforum.org/global-competitiveness-report-2015-2016/competitiveness-rankings/

Knowledge-based Capital Synthesis. (2013). Retrieved October 15, 2016, from https://www.oecd.org/sti/inno/knowledge-based-capital-synthesis.pdf

Looking to the 70s Oil Crisis for Lessons in Energy-Saving. (2012). Japan Center for Economic Research. Retrieved November 7, 2016, from https://www.jcer.or.jp/eng/pdf/m38_topic.pdf

National Accounts (NIPA) - Domestic Product and Income. (2016). Bureau of Economic Analysis. Retrieved October 30, 2016, from http://bea.gov/histdata

National Accounts (NIPA) – Saving and Investment. (2016, October 28). Bureau of Economic Analysis. Retrieved October 30, 2016, from http://bea.gov/histdata

Strain, M. (n.d.). Definition of "Spillover Costs" Retrieved October 16, 2016, from http://smallbusiness.chron.com/definition-spillover-costs-39166.html

The FRASE Index - The Impact of Federal Regulation on the 50 States. (n.d.). Retrieved from http://regdata.org/50states/

World Energy Outlook 2014 Factsheet. (n.d.). International Energy Agency. Retrieved October 16, 2016, from https://www.iea.org/

9. APPENDIX A

Materials	Information Technology
Albemarle	Alliance Data Systems
Avery Dennison	Akamai Technologies
Ball	Activision Blizzard
CF Industries Holdings	Cognizant Tech Solns
E.I. du Pont de Nemours	Citrix Systems
Dow Chemical	eBay
Ecolab	Facebook
Eastman Chemical	Fidelity National Info
Freeport-McMoRan	Fiserv
FMC	First Solar
International Flavors	Alphabet
International Paper	IBM
LyondellBasell Industries	Intel
Martin Marietta Materials	Juniper Networks
Mosaic	Mastercard
Newmont Mining	Motorola Solutions
Nucor	Netflix
PPG Industries	PayPal Holdings
Praxair	Teradata
Sealed Air	Total System Services
Sherwin-Williams	Texas Instruments
Vulcan Materials	VeriSign
	The Western Union
	Xerox
	Yahoo!