Economics 620

Allegheny College
Meadville,
Pennsylvania
16335

Growth and Investment in America



Author: Cameron Day
Date: April 21st, 2014

TABLE OF CONTENTS

Chapter 1: Characteristics of Investment in Equipment and Software 1968-2011
1.0 Introduction……..…..5
1.1 Models.....8
1.2 Investment: The Engine of Economic Growth…….17
1.3 Conclusion.....18

Chapter 2: Investment Growth and the Theory of the Firm
2.0 Introduction.....20
2.1 The Iso-Cost line: Derivation.....21
2.2 Manipulation of the Iso-Cost line.....25
2.3 Isoquants: Derivation.....27
2.4 Point of Optimality in a Firm's Production.....30
2.5 Comparative Static Analysis.....32
2.6 The Harrod-Domar Model.....37
2.7 Conclusion…….……..37

Chapter 3: Investment in Equipment and Software: Empirical Analysis
3.0 Introduction.....39
3.1 Regression Analysis, An Overview.....39
3.2 Data and Regression Results.....41
3.3 T-Statistic and Test of Significance ……..…….....46
3.4 Conclusion.....49

Chapter 4: Conclusion.....51

Bibliography…….……54

About the Author…….……55

Abstract

The purpose of this study is to examine the determinants of investment in equipment and software in the United States from 1968-2011. Investment in equipment and software is essentially the main driver of growth in the economy; it plays an important role in affecting GDP growth and other major indicators of economic health. This study's main goal is to find out which variables could be stimulated to best increase investment growth. By increasing investment growth in America, Americans could finally escape the effects of the dragging recession that has led to slow rates of economic growth since 2007. According to Romer, "One of Burns and Mitchell's key insights was that many economic indicators move together. During an expansion, not only does output rise, but also employment rises and unemployment falls. New construction also typically increases, and inflation may rise if the expansion is particularly brisk" (Romer). This "new construction" that Burns and Mitchell referred to is investment in capital; moreover, investment in equipment and software has a similar relationship in that it moves with many economic indicators. Investment in equipment and software not only directly correlates with overall investment but could have an impact on social returns to equipment and investment. Some possible social returns to equipment and investment are higher standards of living and increased productivity.

After evaluating the determinants of investment in equipment and software, I now have a better understanding of the relationships between all of the independent variables used in my study and my dependent variable. Upon running and analyzing a regression, I have found that four independent variables are significant; real manufacturing output during years of expansions and contractions, real wage growth during years of economic contraction, and productivity growth led 1 year ahead of years of economic expansion. This means that the behavior of

investment in equipment and software is primarily explained by the behavior of these independent variables. Therefore, in order to best stimulate GDP growth to escape a recession, we should focus on increasing real manufacturing output, decreasing real wage growth, and increasing productivity growth.

Chapter 1
Characteristics of Investment in Equipment and Software 1968-2011

1.0 Introduction

The purpose of this study is to examine the determinants of investment in equipment and software in the United States from 1968-2011. Investment in equipment and software is essentially the main driver of growth in the economy; it plays an important role in affecting GDP growth and other major indicators of economic health. This study's main goal is to find out which variables could be stimulated to best increase investment growth. By increasing investment growth in America, Americans could finally escape the effects of the dragging recession that has led to slow rates of economic growth since 2007. According to Romer, "One of Burns and Mitchell's key insights was that many economic indicators move together. During an expansion, not only does output rise, but also employment rises and unemployment falls. New construction also typically increases, and inflation may rise if the expansion is particularly brisk" (Romer). This "new construction" that Burns and Mitchell referred to is investment in capital; moreover, investment in equipment and software has a similar relationship in that it moves with many economic indicators. Investment in equipment and software not only directly correlates with overall investment but could have an impact on social returns to equipment and investment. Some possible social returns to equipment and investment are higher standards of living and increased productivity.

The purpose of this chapter is to provide an introduction to the determinants of investment in equipment and software and total investment that I analyze in this paper. The following is a definition of investment in equipment and software from the Bureau of Economic Analysis:

Investment in equipment and software consists of capital account purchases of new machinery, equipment, furniture, vehicles, and computer software; dealers' margins on sales

of used equipment; and net purchases of used equipment from government agencies, persons, and the rest of the world. Own-account production of computer software is also included.

Basically, investment, particularly in equipment and software, is the driving force of an economy. If companies did not invest in these goods, growth would be sluggish or non-existent. For example, according to Clark and Nakata, a sluggish economy is often the result of high unemployment. During periods of high unemployment, the labor force participation rate (LFPR) is lower than average, and companies are not hiring as many workers. When firms restrict investment in equipment and software as well as human capital, the unemployment rate remains high. Given a low level of investment by firms, the economy will remain sluggish and growth will stagnate.

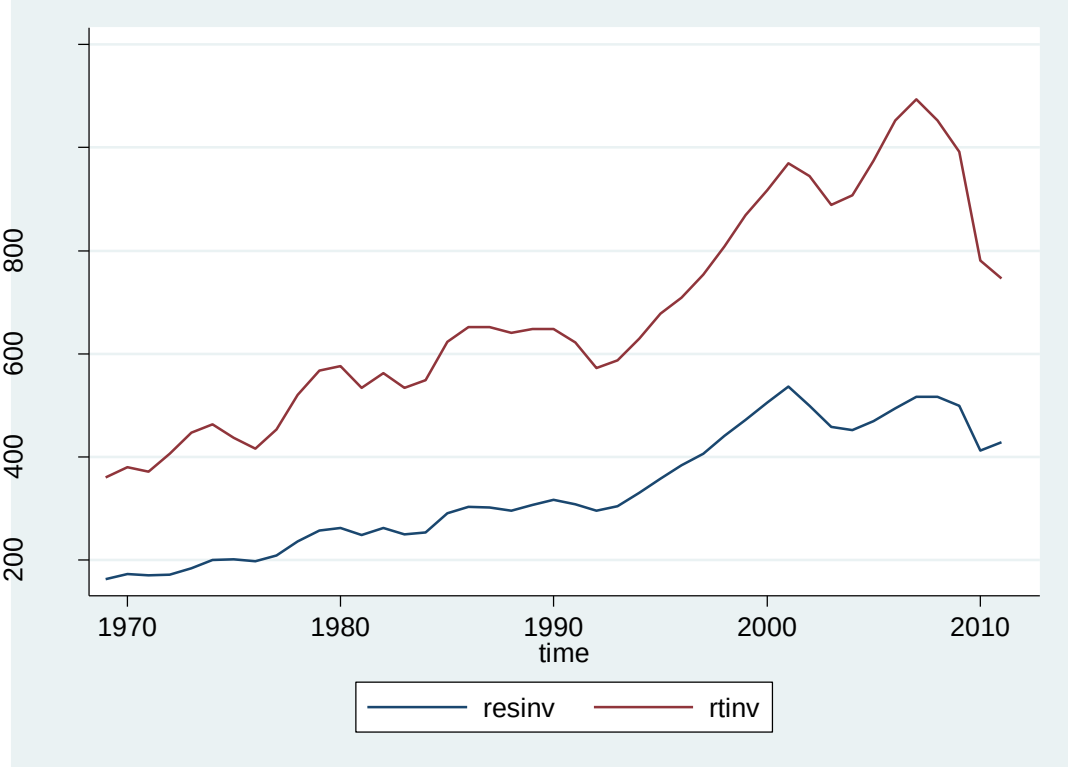
As a result of this relationship, I expect a strong positive correlation between the growth in investment of equipment and software and the growth in GDP. I don't expect there to be much of a lag in the growth rate of GDP compared to the growth rate in investment of equipment and software, because investment is a large component of GDP and directly affects it. Furthermore, higher levels of investment will lead to higher levels of GDP in the future because businesses are able to be more productive with enhanced equipment and software. The accelerator model of investment describes how shocks that affect investment affect output in sectors that produce durable goods. Additionally, since investment is a component of GDP, I also expect to see a strong relationship between real investment and real GDP. During times of recession, where GDP growth is low, I also expect that investment growth will be low. As Romer states, "…during a recession, the output of goods and services declines, employment falls, and unemployment rises; new construction also declines" (Romer). As a result, Americans can expect a similar effect on investment in equipment and software during a recession. However, I

will explore whether or not the various components of investment in equipment and software move with the same degree of timing and volatility as total investment.

To begin the analysis of the determinants of the growth rate of investment in equipment and software, I compare and contrast various determinants of investment and explore their relationships. I study different details about each variable such as how big it is, whether or not it is pro-cyclical or volatile, etc. All of the raw data for variables described in this chapter are found in Table 1.1 in the Appendix.

1.1 Models

Figure 1.1 Real Investment in Equipment and Software VS Total Real Investment



Source: Based on data from Table 1.1 (appendix) and author's Stata calculations.

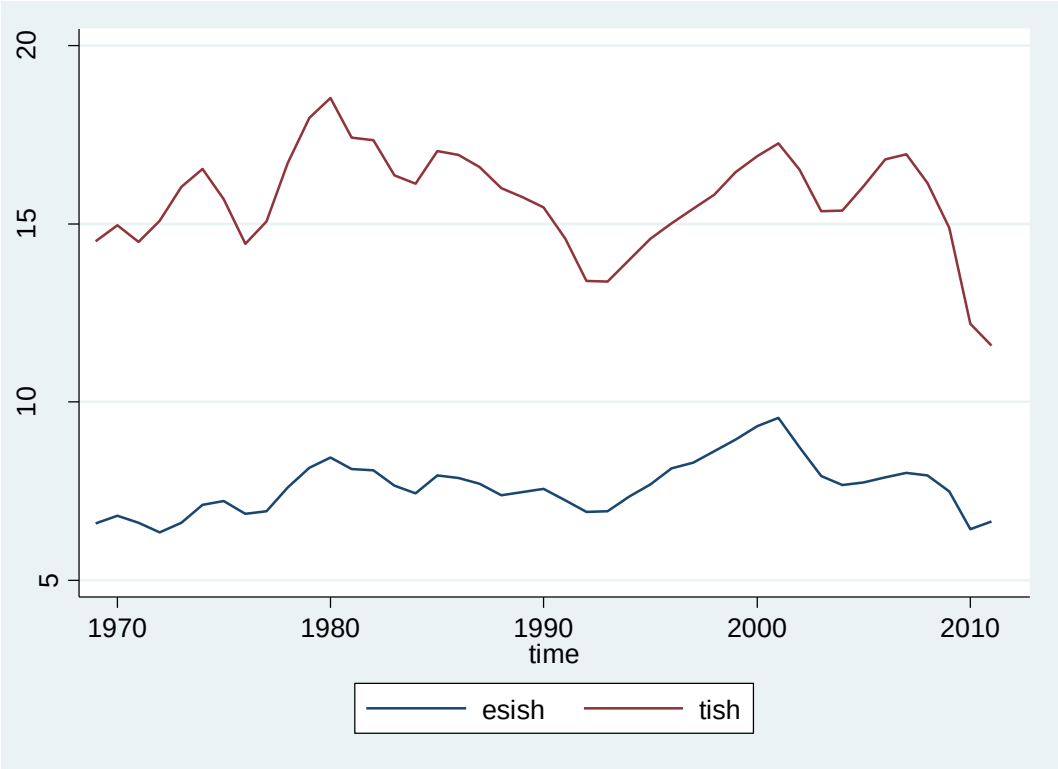
First, since real investment in equipment and software (resinv) is a subset of total real investment (rtinv), I compare the values of each, measured in trillions of dollars. Figure 1.1 shows that both real investment in equipment and software and total real investment have increased greatly over time. Specifically, during the tech boom from 1990-2000, investment soared until the dot com crash in 2000. Interestingly, both graphs mirror each other very closely, which makes sense because real investment in equipment and software is a large component of total real investment. Both investment functions tend to be recession prone, which means that during recessions, both investment in equipment and software and total investment decrease greatly. For example, during the most recent recession, real investment in equipment and

software decreased by 20.3% from 2007-2010 while real total investment decreased by nearly 28.6% during the same time frame.

During times of economic hardship, businesses tend to invest less for a couple reasons. The first is that, typically during the peaks of expansions and early phases of recessions, the interest rate tends to be high relative to the rate of return on investment, which makes it relatively more expensive for businesses to borrow and invest. Second, businesses are unsure of the future and as a result tend to hold on to money instead of spending it. According to Keynes, "tension in the bond and money markets is unfavorable to the continuance of prosperity, not only because high rates of interest reduce the prospective margins of profit, but also because they check the expansion in the volume of trade out of which prosperity developed" (Mitchell, p. 51). Given the role that the interest rate plays in determining how businesses behave, perhaps it would be wise to reflect on Keynes' view on economic growth.

In "Keynes on the Sources of Economic Growth" by Vincent Tarascio, the author presents Keynes' view on the effect of population change. Tarascio's major findings include that Keynes believed that both population change and technological change affected the demand for capital, thereby affecting economic growth. In retrospect, I can't help but wonder if Keynes could have predicted the rapid increase in technological change of today's economy?

Figure 1.2 Real Investment in Equipment and Software Share of GDP VS Total Real Investment Share of GDP:

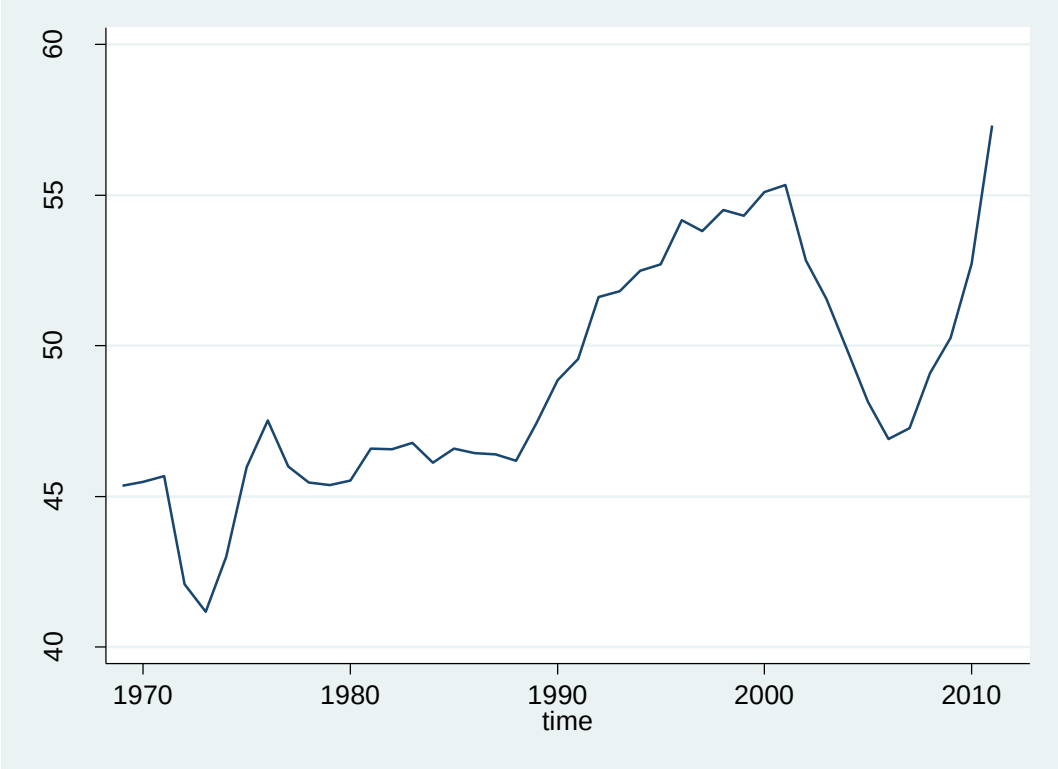


Source: Based on data from Table 1.1 (appendix) and author's Stata calculations.

Figure 1.2 shows just how closely real investment in equipment and software's percentage share in GDP (esish) compares to total real investment's percentage share in GDP (tish). During years of recessions, both graphs decrease because investment decreases during times of economic hardship. As a result, investment tends to be pro-cyclical. Observing Figure 1.2 we see that total real investment's share in GDP is more volatile than real investment in equipment and software's share in GDP. Again, there is a large decrease in overall real investment during the Great Recession in 2009. This decrease is represented in the investment of equipment and software, but to a much smaller degree and shows signs of recovery following 2010. Over the 1969-2011 time period, the average real investment in equipment and software percentage share in GDP is 7.62%, while the average total real investment percentage share in

GDP is 15.67%. As a result, I conclude that real investment in equipment and software makes up approximately half of total real investment, on average. In Figure 1.3, I explore this relationship further to test this hypothesis.

Figure 1.3 Real Investment in Equipment and Software as a percentage of Total Real Investment



Source: Based on data from Table 1.1 (appendix) and author's Stata calculations.

Figure 1.3 shows just how large a part of total real investment that real investment in equipment and software is. Overall, since 1969, real investment in equipment and software has grown as a share of total real investment from 45.34% to 57.3%. This is not surprising due to the more advanced computer technology of today. Naturally businesses want to become more tech savvy to the degree that it makes them more competitive and, as a result, invest a larger portion of their revenues in expensive technology. During the tech bubble of the 90s, real investment in equipment and software as a share of total real investment increases by approximately 10%.

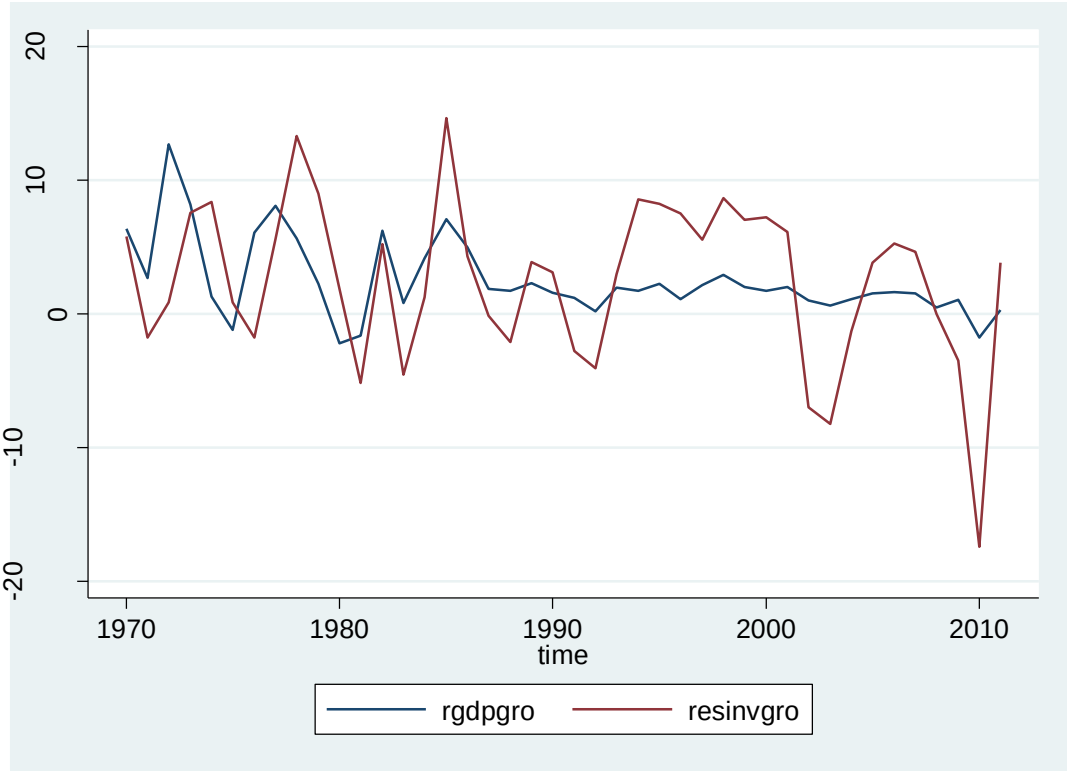
Interestingly, during the recession of 2009, the real investment in equipment and software skyrocketed as a percentage of total real investment. However, this result is not due to an increase in real investment in equipment and software, but from a decrease in total real investment. In fact, from the data, real total investment decreased from $1.09 trillion in 2007 to $746 billion in 2011. Additionally, Figure 1.1 shows that total real investment decreased greatly during the latest recession. Wesley Mitchell's observations from nearly 70 years ago that still hold true today. According to Mitchell, "…it is important to note that different industries are affected by business cycles in different ways. Some industries, for example, are hit early and hit hard by a decline in business activity, while other industries are affected by slightly" (Mitchell, p. 46). For example, during the 2007-09 recession, employment in the construction industry decreased by 19.8% while employment in the education and health services sector increased by 3.3%. During the Great Recession, most sectors of the economy were negatively impacted leading to decreased investment across the board. This explanation by Mitchell further reinforces why real investment in equipment and software increased as a share of real total investment during the Great Recession of 2009.

Christopher J. Goodman and Steven M. Mance provided an excellent overview of the major impacts from the Great Recession. In their article "Employment loss and the 2007-09 recession: an overview" the authors evaluate the effect that the 2007-09 recession had on unemployment. First, the authors argue that the rising housing prices led to an increased wealth effect. This resulted in consumers increasing their consumption because their perceived wealth was higher. Second, oil prices increased dramatically in the beginning of the recession. Combined with increased oil prices and falling housing prices, personal consumption decreased, which lead to decreased spending resulting in job loss. Third, the largest job declines occurred in

service providing industries. Of course there were employment losses in every sector of the economy as well, except for the federal government. Since the federal government does not have as strict a budget as lower levels of government, it was able to increase their jobs.

Goodman and Mance's major findings include that the 2007-09 recession was much worse in magnitude than most recessions in recent memory. "Virtually no area of the economy remained unscathed from the December 2007-June 2009 recession, particularly the labor market" (p. 3). Basically, the "Great Recession" was a perfect storm of increased oil prices, decreased housing prices, and the constricted credit market.

Figure 1.4 Real Investment in Equipment and Software Growth VS Real GDP Growth:

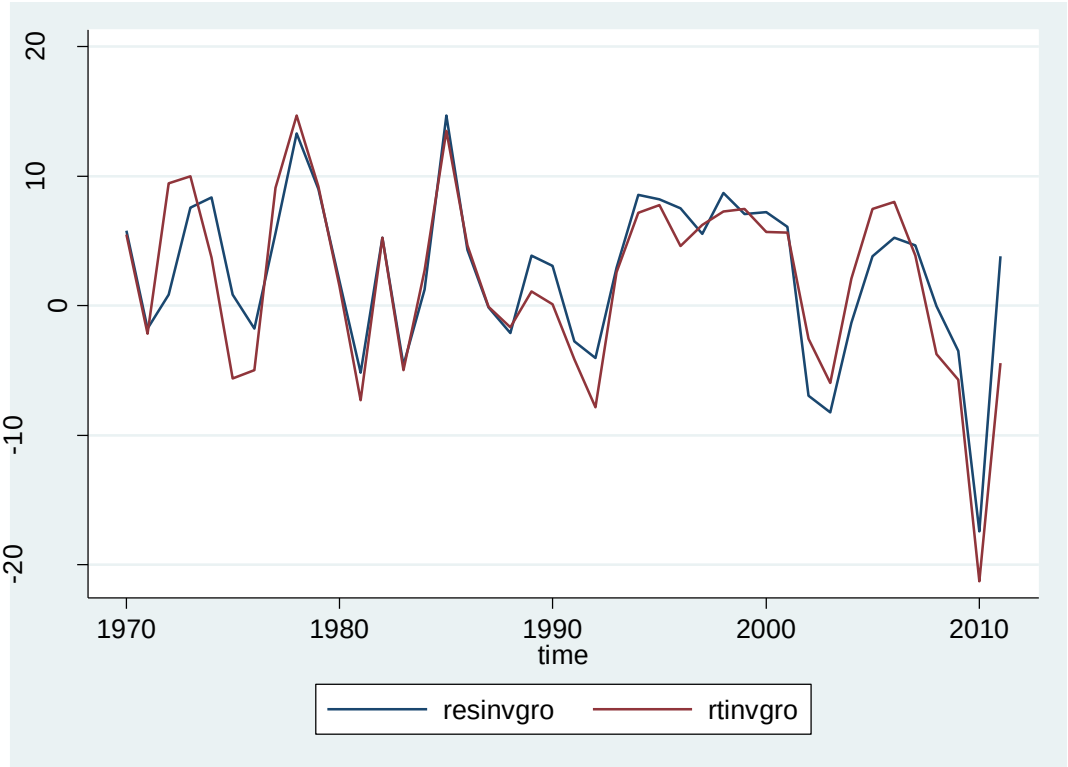


Source: Based on data from Table 1.1 (appendix) and author's Stata calculations.

Figure 1.4 shows that the percentage growth values in real investment in equipment and software (resinvgro) tend to be much more volatile than the percentage growth values of real GDP (rgdpgro). Also, based on Figure 1.4, there is evidence of the structural change that took

place starting in 1984. According to Davis and Kahn, "An abrupt drop in the volatility of U.S. real GDP growth in the early 1980s…provided the initial impetus for research on the Great Moderation." The Great Moderation resulted in less volatile growth values in GDP and generally smaller increases in real investment in equipment and software growth. For example, in 2010, after the Great Moderation, the real investment in equipment and software growth rate decreased by 17.4%, while real GDP growth only decreased by 1.8%. This result is similar across the board: real investment in equipment and software growth tends to be much larger in value than real GDP growth. Prior to 1984, it appears that real investment in equipment and software growth was a lagging variable by about one year. Following the Great Moderation, it appears that both variables in Figure 1.4 are moving with each other, or coincidently.

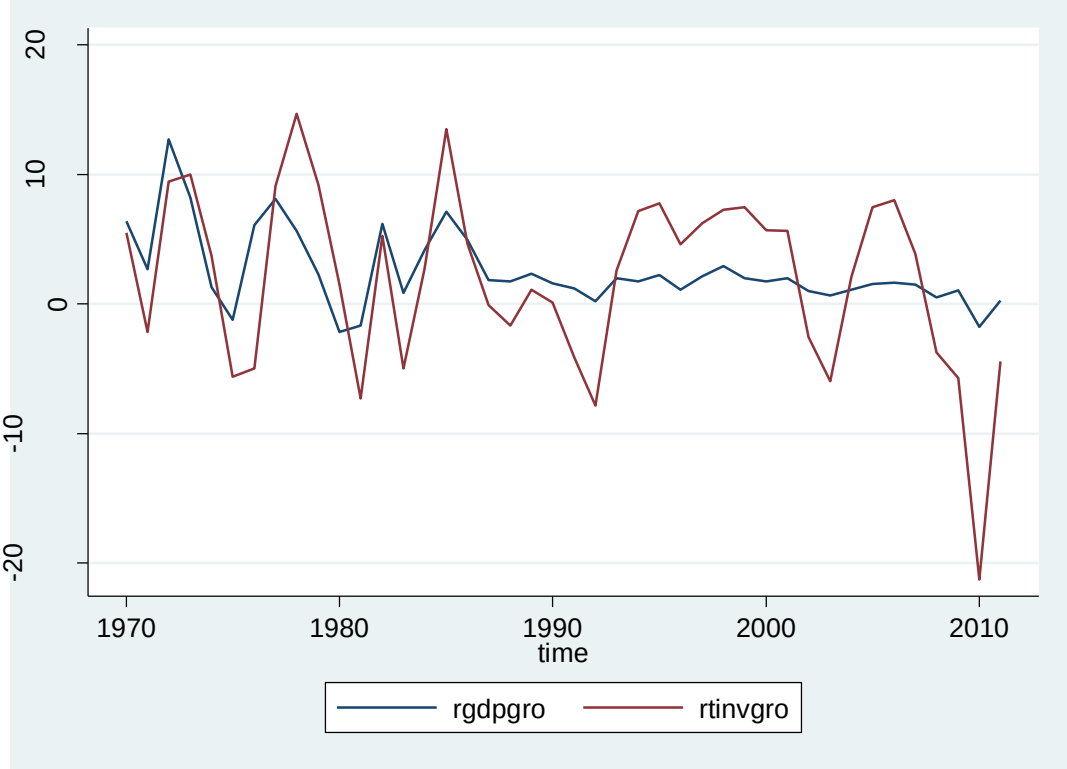
Figure 1.5 Real Investment in Equipment and Software Growth VS Total Real Investment Growth



Source: Based on data from Table 1.1 (appendix) and author's Stata calculations.

Figure 1.5, shows that real investment in equipment and software growth (resinvgro) almost perfectly mirrors total real investment growth (rtinvgro). Both growth values tend to be very volatile, which is consistent with the other graphs that have been shown. Additionally, growth values tend to be strongly negative during times of recession and moderately positive during times of economic growth. Additionally I would argue that, other than during the Great Recession of 2009, growth values for both variables have been smaller, on average, since the beginning of the Great Moderation in 1984. Furthermore, the Great Moderation tended to lower the peaks of these growth values but the troughs seem to have gotten worse. According to Davis and Kahn, "most advanced economies have experienced a striking decline in the volatility of aggregate economic activity since the early 1980s. Volatility reductions are evident for output and employment at the aggregate level and across most industrial sectors and expenditure categories". Basically, beginning in approximately 1984, growth rates in a number of different sectors have tended to not be as subject to change as before. Also, on average, it appears that total real investment growth is a little more volatile than real investment in equipment and software growth. Moreover it appears as though both variables move in a coincident manner with each other, neither one leading or lagging.

Figure 1.6 Real Total Investment Growth VS Real GDP Growth



Source: Based on data from Table 1.1 (appendix) and author's Stata calculations.

In the final graph, I show the relationship between real total investment growth and real GDP growth, with the goal of analyzing the relationship between them. Figure 1.6 shows many similarities that existed between real total investment growth (rtinvgro) and real GDP growth (rgdpgro). Both of the variables tend to move with each other, and real total investment growth is much more volatile than real GDP growth, on average. Since we saw how closely real investment in equipment and software growth and real total investment growth mirrored each other in Figure 1.5, we should expect this graph to mirror that in Figure 1.4. Again, structural change in the form of the Great Moderation appeared in the rate of real GDP growth since 1984, because, as a result of the Great Moderation, GDP growth rates have become much more stable than they were prior to 1984.

1.2 Investment: The Engine of Economic Growth

As the previous graphs have shown, investment plays a large role in economic growth and that is why studying how to best stimulate investment growth, thereby stimulating economic growth, is important. Many authors have contributed theories and ideas to the study of investment and economic growth. It is worthwhile to review some of the most notable contributions and to integrate them into this study.

In the article "Stimulating Economic Growth" found on the World Economic Forum, the recent economic recession and possible solutions are discussed. First, the article states that economic conditions are not as bad as they appear. The standard of living has been vastly increasing and given how fast technological changes, which are embodied in investment in equipment and software, have been occurring, things are likely to keep getting better. Second, economic growth can be sustained by investing in four major factors. "There are four key priorities for achieving sustainable economic growth: education, social stability, incentives for taking risks, and global economic integration." Basically by achieving these four key priorities, we will be able to better sustain investment growth, thereby achieving GDP growth.

The major findings in this article include that the rate of technological advancement and standard of living have been increasing for a long time. Additionally that by prioritizing education, social stability, incentives for taking risks, and global economic integration, economic growth will become more sustainable.

In the article "Equipment Investment and Economic Growth" by Bradford De Long and Lawrence Summers, the authors try to explain the correlation between investment in equipment and economic growth. First, the authors note that European historians have long seen the richest countries to be the countries that invent the most useful capital. By having this more productive

capital, these countries attain an advantage over other countries. Second, the authors note that those countries that invested in capital heavily in the period 1960-1985, enjoyed high growth over the same time period. Third, the authors attempt to determine whether growth causes investment or that, more likely, investment causes growth. "One reason to believe that equipment investment causes growth, rather than that growth causes investment, is that if growth caused investment we would expect to see similar associations between equipment and structures investment and growth" (p. 469).

In the article "Equipment Investment and Economic Growth" Jonathan Temple sets out to study the correlation between equipment investment and economic growth and it's compatibility with the Solow model. First, Temple presents the necessary theory and runs the appropriate regressions to see the explanatory power that equipment investment has on economic growth. He finds that there is more explanatory power for equipment investment in developing countries. Second, he concludes that equipment investment has a higher social benefit, such as increased standard of living, in lesser developed countries, where the standard of living tends to be lower than it is in developed nations. Third, the author concludes that investment should be moved more into equipment rather than structure because there is higher resulting economic growth from investing in equipment rather than in structures.

1.3 Conclusion

This chapter has examined the relationship between GDP, which is the most important determinant of real investment in equipment and software, and compared them with the goal of better understanding the relationship between the two variables. Given the most recent recession whose effects many claim still linger, the objective of this study is to discover which variables could be stimulated to best increase investment growth. By manipulating these variables to

increase investment, perhaps we could finally end the period of slow growth since the Great Recession. In the chapters that follow, I use the theory of cost minimization and empirical evidence to study how investment in equipment and software has varied over time due to change in its determinants. I take advantage of iso-cost lines and isoquants to compare different potential optimal input levels needed to produce for a desired level of output for firms. Additionally, I use empirical evidence and perform regression analysis to test my hypothesis, which is based on theory. Furthermore, I investigate the behavior of investment in equipment and software and total investment over time in the United States and attempt to explain relationships that exist.

Chapter 2
Investment Growth and the Theory of the Firm

2.0 Introduction

Americans have been stuck in an economic slump for the past 7 years, but there is reason to hope! The purpose of this study is to evaluate the determinants of investment growth. So, because investment growth is so important in affecting GDP growth, by finding which determinants of investment growth are most important, the factors that best increase GDP growth can be identified. Towards this end, this chapter makes use of the cost minimization model. By graphing iso-costs and isoquants with one another, we are able to determine a point of optimality for firms. With this point of optimality, it is possible to determine the best combination of capital and labor to use in order to produce a given level of output. Furthermore, we are able to predict how firms react to changes in prices of inputs, the desired level of output, or technology. One of the most notable economists to study economic growth and to discuss how to best provide a model for economic growth was Robert M. Solow.

In the article "A Contribution to the Theory of Economic Growth" Solow evaluates how assumptions made in the process of creating theory can affect the theory. First, the author argues that crucial assumptions of theories must be reasonably realistic and that there exists a tipping point at which certain assumptions fail. Once this failure occurs, the theory will not prove true anymore. The author makes use of the Harrod-Domar model's assumption of fixed proportions of economic growth as an example. Second, the author emphasizes that by using more flexible assumptions concerning production, we would create a simpler model. "My purpose was to examine what might be called the tightrope view of economic growth and to see where more flexible assumptions about production would lead to a simple model." According to Solow, if we are able to make more reasonable and flexible assumptions about different independent

variables, such as production or the supply of labor, perhaps we will be able to create simpler theories with fewer assumptions.

Solow's major findings include that, by simplifying the assumptions made in the attempt to create a model or theory, perhaps we would be able to produce a theory or model that has less exceptions and holds true more of time. Solow also made use of the Harrod-Domar model of economic growth as an example of how to simplify the assumptions made in the process of producing a theory or model. Therefore, based on Solow's observations regarding model building, the key model used in this chapter is the well-known theory of cost minimization. The sections that follow provide a theoretical background to the cost minimization model that will be utilized throughout this study.

2.1 The Iso-Cost line: Derivation

According to Robert Hall and Marc Lieberman, the iso-cost line is defined as all input combinations with the same cost. To begin the derivation of the iso-cost line, we are given two inputs, capital (K) and labor (L), their prices, the capital rental rate (R) and the wage (W), and cost, C. The firm's total cost is defined as input combinations multiplied by their respective prices. In particular, the capital rental rate, R, is influenced by the cost to invest, which includes the interest rate. The total cost to invest can be written in equation form:

$$C = RK + WL$$

By setting labor = 0, we see that,

$$C = RK + W(0) = RK$$

After dividing the cost by the capital rental rate, we see how many units of capital can be rented when only capital is purchased,

$$K = C/R$$

By doing the opposite and setting capital = 0, we see that,

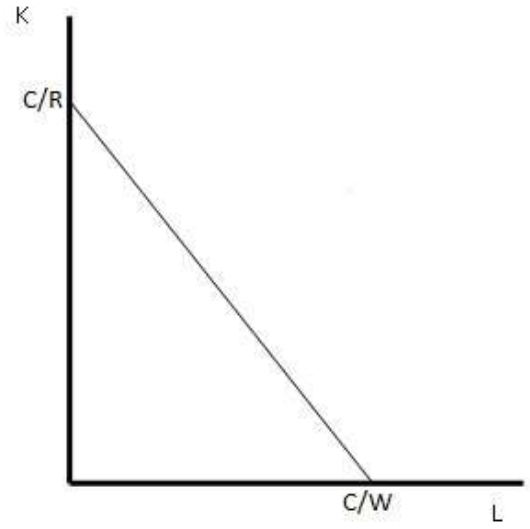
$$C = R(0) + WL = WL$$

Again if we divide the cost by the price of labor, we can see how much labor can be afforded if the firm only uses labor with a fixed cost,

$$L = C/W$$

With capital graphed along the vertical axis and labor graphed along the horizontal axis, we obtain Figure 2.1,

Figure 2.1: The Iso-Cost Line



In Figure 2.1, the vertical axis intercept represents an input combination consisting of all capital and no labor. And the horizontal axis intercept represents an input combination consisting of no capital and all labor.

Let's perform a numerical example to demonstrate the characteristics of the iso-cost curve. Assume that total cost (C) = $100 and that wages (W) are set at $10 per worker and the capital rental rate (R) is set at $5 per unit of capital.

Therefore, since $C = WL + RK$,

$$\$100 = \$5K + \$10L$$

If we have 0 units of capital,

$$\$100 = \$5(0) + \$10L$$

$$\$100 = \$10L$$

Simplifying further, we find:

$$10 = L$$

Therefore, the horizontal intercept is equal to 10 units of labor. Alternatively, if we have 0 units of labor, then:

$$\$100 = \$5K + \$10(0)$$

After simplification, we find:

$$\$100 = \$5K$$

$$20 = K$$

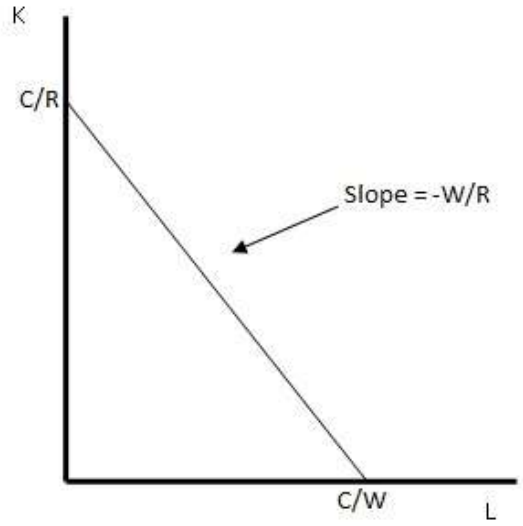
Therefore, the vertical intercept is equal to 20 units of capital.

The slope of the iso-cost line is found by dividing the rise of the line by the run:

$$Slope = \frac{Rise}{Run} = \frac{-\frac{C}{R}}{\frac{C}{W}} = \frac{-C}{R}\left(\frac{W}{C}\right) = \frac{-W}{R}$$

Figure 2.2 shows the slope of an iso-cost line, which represents the rate at which capital must be substituted for labor, holding cost constant.

Figure 2.2: Slope of an Iso-Cost Line

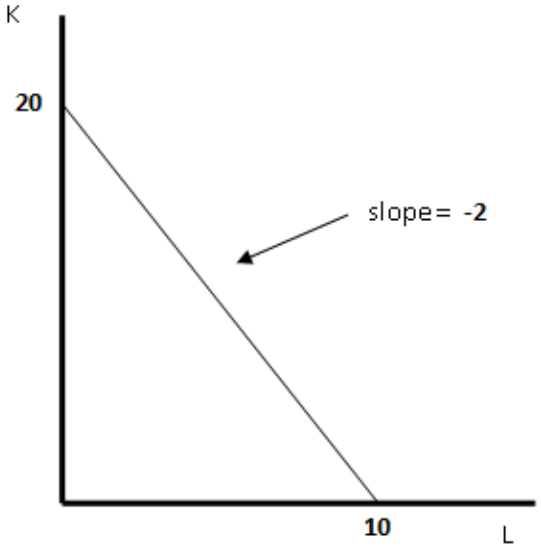


Again, let's consider a numerical example of the slope of the iso-cost curve given the same information as before. We can calculate the slope as,

$$Slope = \frac{Rise}{Run} = \frac{-W}{R} = \frac{-\$10\ per\ worker}{\$5\ per\ unit\ of capital} = -2\ units\ of\ capital\ per\ worker$$

These values appear in Figure 2.3,

Figure 2.3: Calculating Slope of an Iso-Cost Line



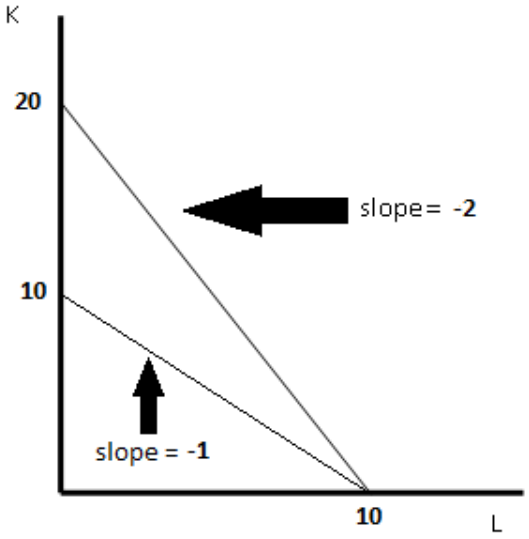
Based on this example, the firm must sacrifice 2 units of capital for each additional unit of labor to keep cost constant. Likewise, since labor is twice as expensive as capital, it must

sacrifice 1 unit of labor for an additional 2 units of capital to keep cost constant. Of course this rate of substitution can change if either of the input prices change, as we demonstrate shortly.

2.2 Manipulation of the Iso-Cost line

As noted by Hall and Lieberman, there are three different scenarios that can affect a firm's iso-cost line. In Figure 2.4, the price of capital increases, which decreases the number of units of capital a company purchases at the given cost. Let total cost = \$100 and assume that W = \$10 per unit and R = \$5 per unit initially. Next, suppose that the price of capital increases to R = \$10 per unit. Since the price of capital has increased, $\frac{C}{R}$ fell from $\frac{100}{5} = 20$ to $\frac{100}{10} = 10$. This means that, before the capital price increase, the firm could afford 20 units of capital and 0 units of labor, but after the capital price increase, the firm could afford 10 units of capital and 0 units of labor.

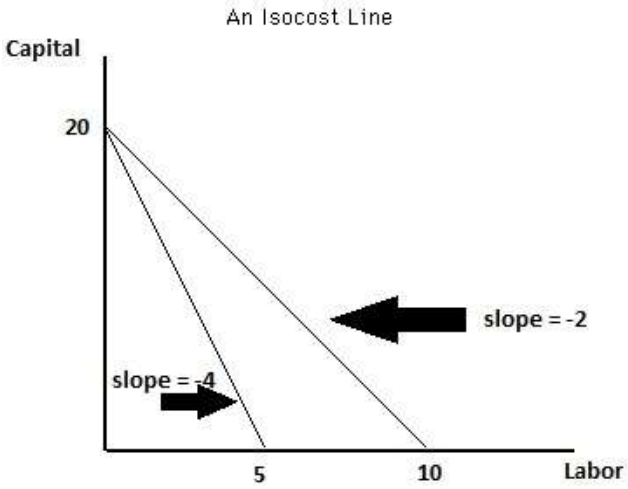
Figure 2.4: Price of Capital Increases



This results in a smaller number of affordable units of capital with the given total cost and also changes the rate at which the firm would substitute capital for labor to maintain a constant cost.

Next, I show how labor price changes affect a firm's iso-cost line. In Figure 2.5, the price of labor increases to W = \$20 per unit, while R = \$5 per unit and C = \$100.

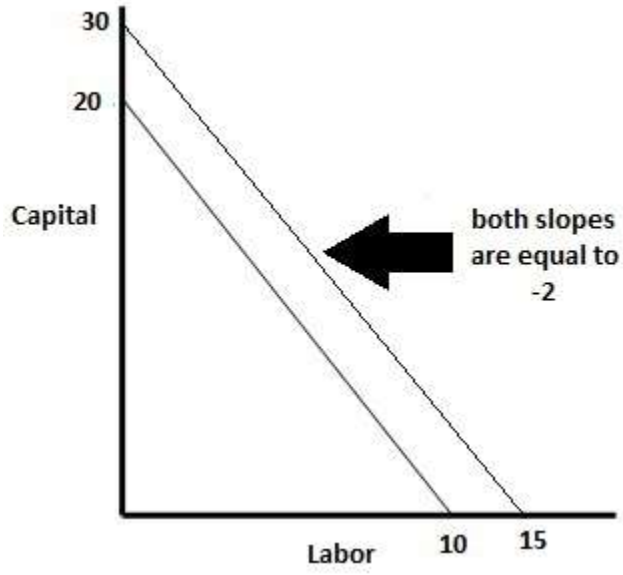
Figure 2.5: Price of Labor Increases



According to Hall and Lieberman, this increase in the price of labor affects the number of units of labor the firm can employ and keep cost constant, which, changes the rate at which the firm would substitute labor for capital. Since the price of labor per unit doubles, the firm can only afford 5 units of labor instead of the previous 10. Moreover, since the cost substitution rate of capital and labor is equal to the slope of the iso-cost line, the substitution rate changes as the input prices change.

In Figure 2.6, the iso-cost line shifts as the purchasing power of the firm increases from C = $100 to C = $150.

Figure 2.6: Total Cost Increases



The rate at which the firm could substitute capital for labor remains constant, but the overall purchasing power has increased, thereby creating a new iso-cost line. Since the price of the inputs has remained constant, the quantity of each input used has increased at a similar rate in accordance with the increase in total cost.

2.3 Isoquants: Derivation

According to the Economics Web Institute, an isoquant is defined as the set of all possible bundles of productive inputs exactly sufficient to produce a given quantity of output. In the sections that follow, the derivation of an isoquant line is reviewed.

Figure 2.7: Isoquants

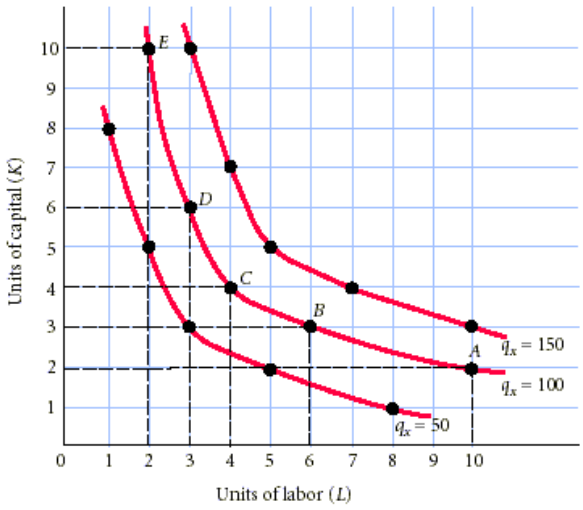


Figure 2.7 displays three different isoquant lines that each show the different combinations of inputs required to produce a desired level of output. Higher isoquants use additional inputs of capital and labor to produce a higher level of output. In theory, a firm has an infinite number of isoquants because there are an infinite number of output possibilities and combinations of inputs to produce a desired level of output. However, it is up to the firm to decide which input combination to use in producing the target output and to decide which one is optimal.

Figure 2.8: Slope of an Isoquant Line

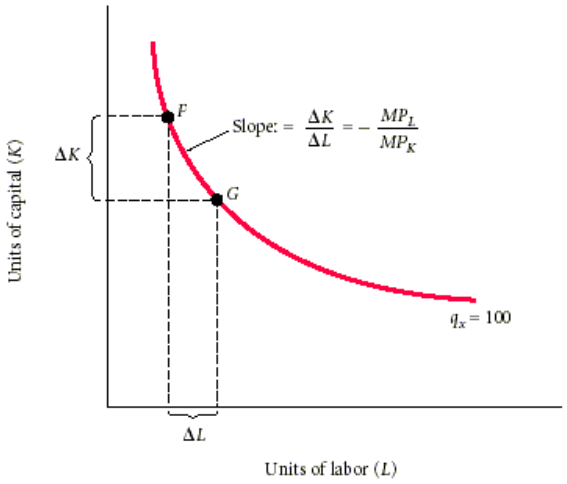


Figure 2.8 demonstrates why the slope of the isoquant is called the marginal rate of technical substitution (MRTS). The MRTS is equal to the ratio of the marginal product of labor to the marginal product of capital, because, in order for output to remain constant, the production lost in using less of one input must be made up for by the gain from using more of the other input. According to Valentino, the marginal product of labor is equal to the rise in output that results from employing an added unit of labor. Similarly, the marginal product of capital is equal to the rise in output that results from utilizing an additional unit of capital.

Specifically, through the implicit function rule,

$$\frac{MP_L}{MP_K} = \frac{\frac{dq}{dL}}{\frac{dq}{dK}} = \frac{dK}{dL}.$$

In terms of the technology available to the firm, the marginal rate of technical substitution reflects the technological tradeoff between capital and labor while holding output constant.

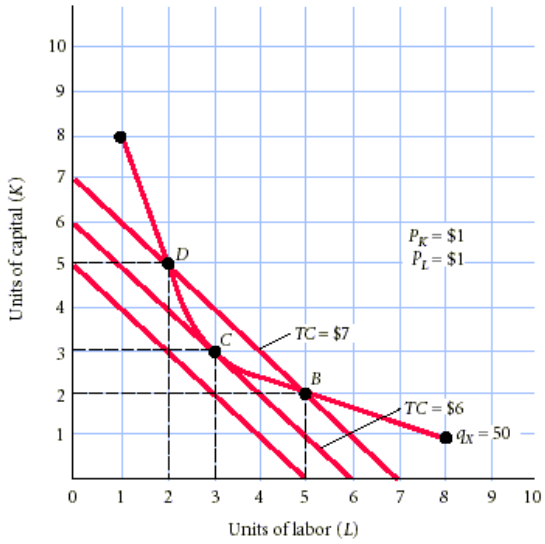
As noted by Piana of the Economics Web Institute, the marginal rate of technical substitution diminishes along an isoquant. As more of one input and less of the other are used in

the production process, it is implied that the more efficient use of inputs involves a fairly equal combination of both inputs. If too much of either input is used, efficiency will decrease. For example, if a lot of labor and a little capital are used, workers will not have enough capital to be productive and will not be as efficient as fewer workers with more capital would be. This would move the company from a flatter point on the isoquant to a steeper point. Having discussed the marginal rate of technical substitution, we now have a clearer idea of how firms go about choosing their ideal combinations of capital and labor in order to produce a desired level of output.

2.4 Point of Optimality in a Firm's Production

As noted by Hall and Lieberman, within a cost minimization model, optimality is defined as the best or most effective combination of inputs to produce a desired level of output. For example, assume that a company needed to produce 50 units of a product. There are infinite combinations of labor and capital that can be used to produce any desired level of output. The firm should be careful not to utilize too much of any one input and too little of the other. Doing so would create an inefficiency and would lead to the company overspending to produce a given level of output. Figure 2.9 demonstrates the point of optimality within a cost minimization model.

Figure 2.9: Point of Optimality within a Cost Minimization Model



It shows the cost minimizing technology at point C, which is the point of tangency of the desired isoquant and the iso-cost. At a point of tangency, the slopes of the two curves are equal; therefore, at point C:

$$\frac{MP_L}{MP_K} = \frac{W}{R} \quad OR \quad \frac{MP_L}{W} = \frac{MP_K}{R}$$

According to Besanko and Braeutigam, this is the condition for producer optimization (where the marginal product per dollar spent should be equal for all inputs purchased.) This condition tells us that, at a cost-minimizing input combination, the additional output per dollar spent on labor services equals the additional output per dollar spent on capital services. Thus, we get equal "bang for the buck" from each output.

Combinations of inputs at other points on the desired isoquant are not optimal because the slopes of the isoquant and iso-cost lines are not equal where they intersect. Instead, the cost of input combination D is higher than C because D lies on a higher iso-cost curve,

$$\frac{MP_L}{P_L} \neq \frac{MP_K}{P_K}$$

In the case where this condition is violated, such as where,

$$MRTS > \frac{R}{W} \rightarrow \frac{MP_K}{R} > \frac{MP_L}{W},$$

the inputs do not have equal additional output per dollar and a more efficient and optimal solution is possible by sacrificing one input for another.

In the ratio, $RTS > \frac{R}{W}$, the slope of the isoquant is greater than the slope of the iso-cost line. Rewritten as $\frac{MP_K}{R} > \frac{MP_L}{W}$, the ratio can be interpreted as the additional output per dollar spent on labor services is less than the additional output per dollar spent on capital services. In this case, to move towards optimality, the firms should use more capital at the expense of labor to produce the same output until $\frac{MP_K}{R} = \frac{MP_L}{W}$.

2.5 Comparative Static Analysis

As noted by the Economic Glossary, comparative static analysis is defined as the technique of comparing the equilibriums, resulting from a change in an exogenous variable. According to the Economic Glossary, comparative statics is the primary analytical technique used in the study of economics. A popular example of this technique is found in the study of markets. Comparative statics is used to analyze how the equilibrium price and equilibrium quantity are affected by changes in the demand and supply determinants, which are graphically represented by shifts of the respective demand or supply curves.

Figure 2.10: Initial Point of Optimality

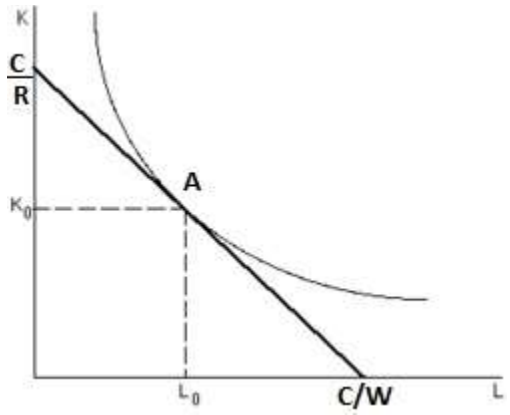


Figure 2.10 shows an iso-cost line and an isoquant meeting at a point of tangency at point A, which is where both slopes of the lines are equal. To demonstrate basic comparative static analysis, the following figures validate how the optimality point changes as input prices and desired output change.

Figure 2.11: An Increase in the Price of Labor

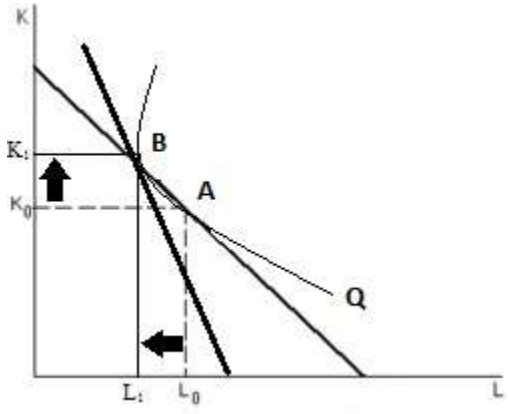
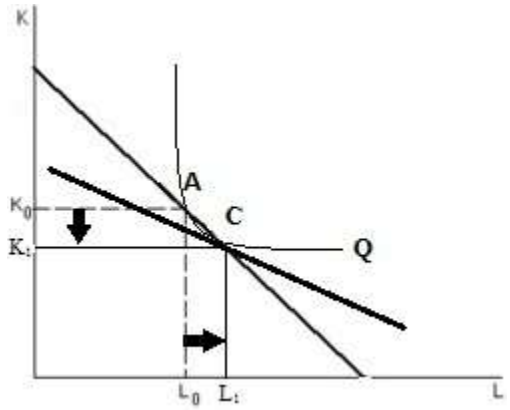


Figure 2.11 shows how the point of optimality is affected by an increase in the price of labor. The price of capital remains constant, as does the desired level of output. Predictably, as the price of labor increases, the slope of the iso-cost, $\frac{W}{R}$, becomes steeper. As a result, the firm will minimize cost by using a greater amount of capital, demonstrated by the movement from

point A to B. Therefore, to maintain optimality in producing the desired level of output, the slope of the iso-cost becomes steeper and the iso-cost line pivots due to the change in price of labor. For example, unions that raise workers' wages cause the price of labor to increase, which leads to relatively more capital utilized by the firms. With the price of labor so high, it is more cost effective in this situation for firms to use more capital than before to compensate for the decreased amount of labor that the firm can afford. Thus, worker's unions can have a large impact on investment in capital by firms.

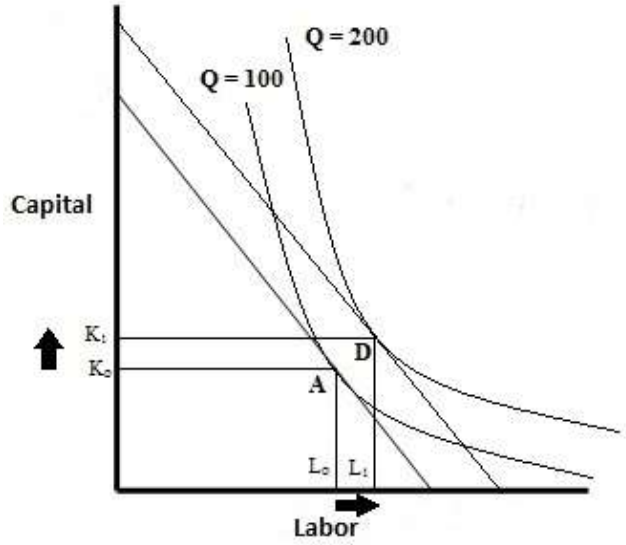
Given this relationship, as the capital rental rate decreases, capital will become comparatively more affordable. This increase in investment will stimulate the economy and lead to a higher GDP growth rate that would be sufficient to push the U.S. out of recession.

Figure 2.12: An Increase in the Price of Capital



Alternately in Figure 2.12, the price of capital is increased, while the price of labor and the desired output level both remain constant. As the price of capital goes up, the firm uses less capital and more labor. This explains the change of the point of optimality from point A to point C. Since production takes place at point C, the slope of the iso-cost becomes less steep and the iso-cost line pivots due to the change in price of capital.

Figure 2.13: An Increase in the Quantity Produced



In Figure 2.13, both of the input prices remain constant, and the desired level of output is increased from 100 units to 200 units. As a result of this increase, the point of optimality for the firm moves from point A to point D. Point D requires additional capital and additional labor to produce the extra output. In the total cost equation,

$$TC = RK + WL,$$

total cost increases, and the wages and rental rate of capital remain constant, the amount of labor and capital must increase to keep the equation valid. Furthermore, as the firm desires a higher level of output, I expect an increase in investment of equipment and software. With an increased amount of equipment and software to work with, the firm will be more able to produce the desired level of output without overworking the existing workers.

Having discussed how the point of optimality for a given firm can change given changes in the inputs or desired level of output, I can now relate this to how a given firm's investment can vary. All firms use various inputs to produce a desired level of output. All the relationships I have discussed thus far concerning changes in the inputs of a firm hold true for all firms. For

example if the price of one input rises, the firm will utilize more of another type of input and less of the relatively more expensive input.

Figure 2.14: An Increase in Technology

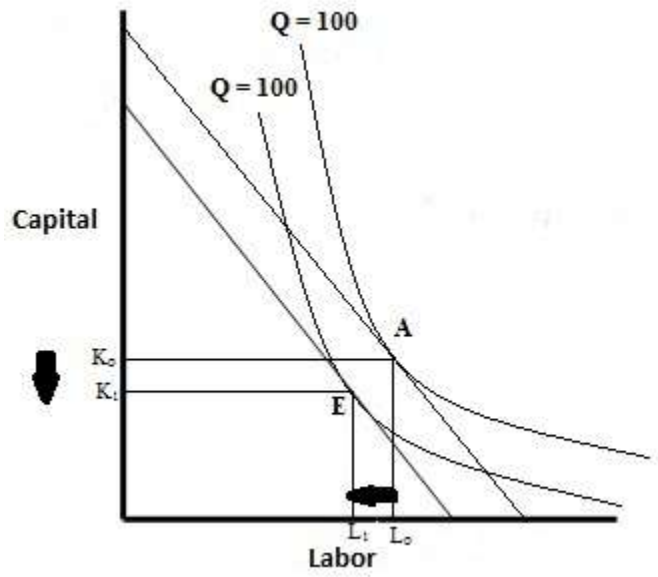


Figure 2.14 shows a situation much the opposite of Figure 2.13. In this case, the firm manages to produce the same level of output with fewer amounts of both inputs, which, in turn, lowers the cost. We see this demonstrated when the point of optimality moves from point A to point E. Since there is technological change in this situation, the isoquant shifts inward. When technological change occurs, often decreased capital and labor are required to produce a constant level of output. As companies purchase more capital, specifically more advanced equipment and software, they are able to produce a given level of output more affordably than before.

This decreases overall costs, the overall price of the output is lowered, the demand for inputs will increase because of the decreased cost and once demand increases the capital and labor inputs will increase. Furthermore we often see demand increase as technological change occurs because everybody wants to keep up with the Jones. In other words, as technology leads

to newer and better products, demand for these new products will increase and further drive companies to invest.

2.6 The Harrod-Domar Model

Among the many models that could be used to derive the relationship between investment and GDP is the Harrod-Domar Model. Dwight Perkins provided a critical analysis of the Harrod-Domar model including its strengths and weakness.

In Economics of Development, by Dwight H. Perkins, the author studies the Harrod-Domar growth model. First, Perkins defines the Harrod-Domar growth model as a production function that assumes capital and labor are used in a constant ratio to determine total output. Second, the author derives incremental capital-output ratio in order to measure the impact on additional capital. Third, the author points out that simplicity is the main strength of the Harrod-Domar model and that the main limitation of the model is that the capital stock and labor force must always grow at the same rate for this model to hold true. "Therefore, generally speaking, the Harrod-Domar framework tends to become increasingly inaccurate over longer periods of time as the actual incremental capital-output ratio changes and with it the capital-labor ratio" (p. 49).

The author's findings include the Harrod-Domar model and its benefits and limitations. The benefit of this model is simplicity and the main limitation is that "since the fixed-coefficient production function requires the capital-labor ratio to be constant, the capital stock and the labor force must always grow at the same rate to maintain equilibrium" (p. 48).

2.7 Conclusion

This chapter has presented the basic theoretical foundation for my study of investment in software and equipment. Based on theory, I expect a positive relationship between investment in

software and equipment and GDP, a measure of output. As shown in Figure 1.4 Real Investment in Equipment and Software Growth vs Real GDP Growth, both variables tend to move together. In fact, there is a direct relationship between them because investment is a component of GDP. We know this because GDP is calculated by adding consumption, investment, government spending and net exports together. As real wages increase, I expect an increase in investment and software because as the substitution rate between capital and labor changes, the firm must act accordingly to maintain the desired level of output. As this substitution rate changes, firms must meet the new increased demand by investing in software and equipment. All else constant, as the price of equipment and software increases, it will have a negative impact on the quantity purchased and for technical substitutions. In the next chapter, I use data to perform empirical analysis to quantify the predictions of the theory that I have presented in this chapter.

Chapter 3

Investment in Equipment and Software: Empirical Analysis

3.0 Introduction

The purpose of this study is to evaluate the determinants of investment in equipment and software growth. By pursuing this objective, I hope to analyze how best to increase investment to stimulate GDP growth. Towards this end, this chapter makes use of regression analysis in order to quantitatively evaluate the relationships between the independent variables and the dependent variable, the investment in equipment and software growth rate. Having previously discussed the theory of cost minimization and the behavior of the firm in the previous chapter, I test my predictions of how the dependent variable is expected to change in relation to my independent variables. In the sections that follow, I describe the independent variables and run a multi-variable regression. I then analyze the results in the hopes of discovering the best way to stimulate GDP growth and to explain the behavior of the investment in equipment and software growth rate.

3.1 Regression Analysis: An Overview

According to Investopedia, a regression model is a statistical approach that attempts to determine the strength of the relationship between one dependent variable and a series of independent variables. A regression model is useful in examining the relationship between a dependent variable and a group of independent variables because the model mathematically finds the coefficients of a linear equation that minimizes the sum of the squared errors. In simple regression, this relationship is typically in the form of a straight line that best approximates all the individual data points. Regression analysis is used to determine which independent variables influence the depend variable, holding all other independent variables constant. The variables in

my regression are split into two groups: during years of economic expansion and years during economic contraction. The fundamental equation of my regression model is,

$$\begin{aligned}\text{inveqsgro} = {} & \text{a} + b_1\text{rmfgexp} + b_2\text{rmfgcon} + b_3\text{rservexp} + b_4\text{rservcon} + b_5\text{rwgroexp} \\ & + b_6\text{rwgrocon} + b_7\text{rpcapexp} + b_8\text{rpcapcon} + b_9\text{prodbl1} + b_{10}\text{proddl1} \\ & + b_{11}\text{dumlead} + b_{12}\text{gmdum} + \text{e},\end{aligned}$$

where inveqsgro is the dependent variable, the growth rate of investment in equipment and software, measured as a percent; a is the model's intercept, the investment in equipment and software growth rate when all other independent variables equal zero; rmfgexp is the growth rate of real manufacturing output during years of economic expansion, measured as a percent; rmfgcon is the growth rate of real manufacturing output during years of economic contraction, measured as a percent; rservexp is the growth rate of real services output during years of economic expansion, measured as a percent; rservcon is the growth rate of real services output during years of economic contraction, measured as a percent; rwgroexp is the growth rate of real wages during years of economic expansion, measured as a percent; rwgrocon is the growth rate of real wages during years of economic contraction, measured as a percent; rpcapexp is the growth rate of real price of capital during years of economic expansion, measured as a percent; rpcapcon is the growth rate of real price of capital during years of economic contraction, measured as a percent; prodbl1 is the growth rate of productivity during years of economic expansion led by 1 year, measured as a percent; proddl1 is the growth rate of productivity during years of economic contraction led by 1 year, measured as a percent; dumlead is a recession dummy variable that equals 1 the year before a recession or 0 during the other years; gmdum is a great moderation dummy variable that equals 1 during a year of the great moderation or 0 during years not involved in the great moderation; and e is the error term that captures the effects of factors not explained by the independent variables.

The coefficient on rmfgexp shows how a 1% increase in real manufacturing output during years of economic expansion is expected to cause investment in equipment and software to rise or fall, on average, holding all other variables constant, while the coefficient on rmfgcon shows the same effect during contractions. The coefficient on rservexp shows how a 1% increase in real services output during years of economic expansion is expected to cause investment in equipment and software to rise or fall, on average, holding all other variables constant, while the coefficient on rservcon shows the same effect during contractions. The coefficient on the remaining quantitative independent variables show how a 1% increase in the independent variable is expected to affect the dependent variable, on average, holding all other independent variables constant. For the qualitative variables the coefficient on dumlead shows how the year before recessions, investment in equipment and software is expected to cause the model's intercept to rise or fall, on average, holding all other variables constant. Finally, the coefficient preceding gmdum shows how during the great moderation, investment in equipment and software is expected to cause the model's intercept to rise or fall, on average, holding all other variables constant.

3.2 Data and Regression Results

According to the theoretical model of investment in equipment and software presented in Chapter 2, investment is a function of manufacturing and services output growth, wages, real prices of capital, and productivity, which serves as a proxy for technical change. Data for investment in equipment and software, in billions of dollars, were taken from Table B1 of the *Economic Report of the President*. Data for manufacturing and services output, in billions of dollars, were taken from Table B8 of the *Economic Report of the President*. Data for real wages, in nominal dollars, were taken from Table B47 of the *Economic Report of the President*. Data for

the price of capital, measured in billions of dollars, were taken from Table B1 of the *Economic Report of the President*. Data for productivity, measured in percent, were taken from Table B49 of the *Economic Report of the President*. Data for both the recession dummy variable is based on whether a recession occurred during a given year according to the National Bureau of Economic Research. The great moderation dummy variable is based on whether or not a given year occurred during the great moderation. All dollar-based data have been transformed into real values. Additionally, all dollar-based data and productivity have been transformed into growth rates, measured as percents.

Table 3.1

Having calculated the results of my regression, now I interpret the results. First, my intercept term is equal to -0.39%, which means that the growth rate of investment in equipment and software will equal -0.39%, on average, when all independent variables equal zero.

Next, I interpret the coefficients for the non-dummy independent variables. The coefficient on my first independent variable, the real manufacturing output growth during years of economic expansion (rmfgexp), equals 1.15, which means that every 1% increase in real manufacturing output during years of economic expansion is expected to cause a 1.15% increase in investment in equipment and software, on average, holding all other variables constant, while, for every 1% increase in real manufacturing output growth during years of economic contraction (rmfgcon), investment in equipment and software is expected to increase by 1.71%, on average, holding all other independent variables constant. Based on the fact that an increase in real manufacturing output growth during years of both economic expansion and economic contraction has such a dramatic impact on investment in equipment and software, perhaps this is one of the best ways to stimulate GDP growth, thereby increasing economic growth.

Similarly, for every 1% increase in real services output growth during years of economic expansion (rservexp), investment in equipment and software is expected to increase by 0.90%, on average, holding all other independent variables constant. Again, for every 1% increase in real services output growth during years of economic contraction (rservcon), investment in equipment and software is expected to decrease by 0.10%, on average, holding all other independent variables constant. Based on these results, during years of economic expansion, stimulating real services output growth would, in theory, have a large impact on investment in equipment and software. By stimulating real services output growth during years of economic expansion, GDP growth could be substantially increased.

Next, for every 1% increase in real wage growth during years of economic expansion (rwgroexp), investment in equipment and software is expected to decrease by 0.22%, on average, holding all other independent variables constant. Alternatively, for every 1% increase in real

wage growth during years of economic contraction (rwgrocon), investment in equipment and software is expected to decrease by 0.72%, on average, holding all other independent variables constant. Since the t-statistic for real wage growth during years of both economic expansion and economic contraction is negative, I would not recommend increasing real wages with the expectation of stimulating economic growth.

Again, for every 1% increase in real price of capital during years of economic expansion (rpcapexp), investment in equipment and software is expected to increase by 0.22%, on average, holding all other independent variables constant, while, for every 1% increase in real price of capital during years of economic contraction (rpcapcon), investment in equipment and software is expected to increase by 0.61%, on average, holding all other independent variables constant. Based on these results, I recommend stimulating real price of capital during years of economic contraction in order to stimulate investment in equipment and software, thereby stimulating economic growth. This impact is not nearly as strong during years of economic expansion so stimulating other independent variables would prove to be a wiser solution.

Finally, for every 1% increase in productivity during years preceding economic expansion (prodbl1), investment in equipment and software is expected to increase by 1.52%, on average, holding all other independent variables constant. In contrast, for every 1% increase in productivity during years preceding economic contractions (proddl1), investment in equipment and software is expected to decrease by 0.12%, on average, holding all other independent variables constant. I decided to lead the measure of productivity by 1 year because the impact of productivity on the dependent variable is often shown the year before. In this way I am able to capture the accurate level of productivity for a given year. Based on these t-statistic values, I

recommend stimulating productivity during years following economic expansion in order to have the greatest impacts on investment in equipment and software.

The coefficient for the recession dummy variable is led by 1 year (dumlead) and is equal to -1.52%, which means that in the year prior to a recession investment in equipment and software is expected to decrease by 1.52% points, regardless of the levels of the other independent variables. Typically, during recessions, investment levels tend to decrease because investors and businesses alike are unsure about the future of the economy, which naturally tends to make them hold their money rather than invest it. Furthermore, during a recession, demand for many normal goods tends to decrease, on average, so it wouldn't make sense for many companies to expand by investing in equipment and software if they are having no problem supplying sufficient numbers of their products. Only during times of economic growth, and a positive economic outlook, when demand is strong, would companies want to invest and expand to meet the increased demand. Because of this, leading the recession dummy variable by 1 year more accurately captures the effects of the recession on investment in equipment and software.

The coefficient for the Great Moderation dummy variable (gmdum) is equal to -0.002%, which means that during the Great Moderation investment in equipment and software is expected to decrease by 0.002% points, regardless of the levels of the other independent variables. According to economists, the Great Moderation refers to a reduction in the volatility of business cycle fluctuations beginning in 1984. This had a significant impact on investment in equipment and software. With a reduction in the volatility of business cycles, recessions weren't as bad, which brightens the economic outlook in comparison to the period before 1984 when recessions were worse. This more positive economic outlook during tough economic times leads to not as large of a decrease in investment in equipment and software. Since the decision to invest is

largely based on emotions and speculations, having a more positive economic outlook is more likely to encourage investing. Regarding the state of economies before the industrial revolution, Keynes believed that, the "…slow rate of progress, or lack of progress, was due to two reasons- to the remarkable absence of important technical improvements and to the failure of capital to accumulate." Basically, Keynes is saying that without investment and improving technology, economic progress will stagnate. As a result, since the Great Moderation betters the economic outlook during times of recession, we expect investment in equipment and software to increase during the Great Moderation.

3.3 T-Statistic and Test of Significance on Real Manufacturing Output Growth During Years of Economic Growth

According to Case and Fair, a t-statistic measures how significant a statistical estimate is. Specifically, a t-statistic can tell us whether or not a particular regression coefficient is statistically significant. By performing a test of significance on an independent variable using the t-statistic, we are able to determine whether or not a particular independent variable is significant.

In my regression, four independent variables were significant and the remaining independent variables and both dummy variables were insignificant. The three that are significant are real manufacturing output growth during years of both economic expansions and contractions, real wage growth during years of economic contraction, and productivity growth led 1 year behind years of economic expansion. Since these independent variables were significant, that means that they had a sufficiently large t-statistic and had a large impact on the dependent variable. In the following example, I test the significance of real manufacturing output growth during years of economic expansion by using a t-test.

First off, by assuming a five percent level of significance, I mean that there is a five percent chance of a type I error. A type I error is the chance of incorrectly rejecting a true null hypothesis. That being said, we first set alpha (α) equal to five percent.

$$\alpha = .05$$

Next, we determine the appropriate null and alternative hypothesis. In this case, the null hypothesis implies that the independent variable, real manufacturing output growth during years of economic recession, is not significant, which means that it does not have a measurable impact on the dependent variable. The alternative hypothesis is based on theory because the coefficient of the independent variable is predicted to be positive. So we set the alternative hypothesis equal to greater than zero.

$$H_0: \beta_1 = 0$$

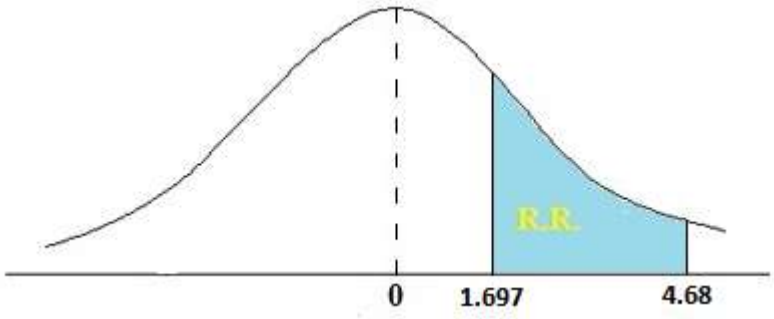
$$H_1: \beta_1 > 0$$

In the following equation that I use to find the t-statistic, b_1 is an estimator of the impact of the independent variable, real manufacturing output growth, on the dependent variable, investment in equipment and software. The estimate is calculated during the regression from our data in Table 3.1. The standard error of the estimate S_{b_1}, is a measure of the accuracy of predictions.

$$t = \frac{b_{1-\beta_1}}{S_{b_1}} = \frac{b_1}{S_{b_1}} = \frac{1.145494}{0.2447243} = 4.68$$

Given that there are thirty degrees of freedom in this model and that the significance level is$\alpha = .05$, the rejection region will at any value at or greater than 1.697. We obtain this number from a table in the appendix of any economics textbook. By using the estimate and standard error from Table 3.1, we are able to calculate a t-statistic that determines the significance of the independent variable. That gives us Figure 3.1, which shows that the t-statistic falls in the rejection region.

Figure 3.1: Right-Tail Test



Given that the t-statistic taken from the regression output of 4.68 does fall within the rejection region, we reject the null hypothesis that the real manufacturing output growth rate during years of economic expansion has no effect on the growth rate of investment in equipment and software. Thus, the real manufacturing output growth rate during years of economic expansion is said to be statistically significant. Similarly, we test any of the independent variables through a similar process to determine their significance. However, for the sake of simplicity, I will make do with this one example, as seen in Table 3.1. The other significant variables, real manufacturing output growth during both years of economic expansion and economic contraction, real wage growth during years of economic contraction, and productivity growth led 1 year behind years of economic expansion, would all have t-statistic values greater than 1.697 because they are significant.

R^2 is a measure that describes the overall fit of the model. A higher R^2 value, closer to one, means that more of the variance of the dependent variable from its mean is explained by the independent variables. This is a desirable outcome because we want the independent variables to have explanatory power and strongly influence the behavior of the dependent variable in a way that matches the theoretical predictions. In my regression, I conclude that the overall fit of my model is pretty good because I have a fairly high R^2 value. Based on my $R^2 = 0.8984$, this means

that 89.84% of the variance of the investment in equipment and software growth rate from its mean is explained by the independent variables.

3.4 Conclusion

This chapter has presented my empirical analysis of investment in equipment and software in the United States from 1968-2011. By running and analyzing a regression, I have gained an understanding of the relationship between each independent variable and my dependent variable. Based on the results from this analysis, I have found that, in particular real manufacturing output during years of expansions and contractions, real wage growth during years of economic contraction, and productivity growth led 1 year behind years of economic expansion are all significant factors that determine the behavior of investment in equipment and software growth. Moreover, the best way to stimulate GDP growth would be to manipulate these variables. Since they have the most explanatory power in determining the dependent variable, changing these variables will have a more powerful effect in stimulating GDP growth. Additionally, through the use of all the independent variables, I have a solid understanding of the determinants of investment in equipment and software. In retrospect, I realize that there are many factors that affect investment in equipment and software growth, but by using this small collection of independent variables I was able to provide a firm explanation for the behavior of investment in equipment and software growth.

When I began this study, I set out with the goal of revealing which of my independent variables could best be stimulated with the purpose of stimulating investment in equipment and software. Under the assumption that increasing investment in equipment and software, will increase economic growth, there were three independent variables that had significant t-statistic values, meaning that if they were stimulated, they would impact investment in equipment and

software the most. These variables are real manufacturing output growth during both years of economic expansion and economic contraction, real wage growth during years of economic contraction, and productivity growth led by 1 year. By stimulating these independent variables appropriately, investment in equipment and software will increase, thereby increasing economic growth.

Chapter 4

Conclusion

This study examines investment in equipment and software in the United States from 1968-2011. Investment in equipment and software is a key indicator of economic growth and plays a key role in affecting GDP growth and other major determinants of economic health. By using various models, I have displayed the relationship between real investment in equipment and software and other key variables. One of the most telling graphs concerning real investment in equipment and software is Figure 1.3 from Chapter 1. Figure 1.3 shows just how large a part of total real investment that real investment in equipment and software is. Clearly, this is a significant indicator of economic health because real investment in equipment and software is such a large portion of GDP.

Another interesting relationship to study is that between real total investment growth and real GDP growth showed in Figure 1.6 from Chapter 1. Figure 1.6 shows how real total investment growth, of which investment in equipment and software makes up a significant percentage, and real GDP growth move with each other. Real total investment growth tends to be more volatile than real GDP growth but more often than not both growth rates tend to move together. This is crucial because by maintaining a positive real total investment growth rate, the real GDP growth rate will also be positive. As a result of a sustained positive real GDP growth rate, the United States economy will continue to grow and we can avoid bad recessions.

Combining this knowledge with an understanding of the cost minimization model further reinforces my study of investment in equipment and software. By studying points of optimality, we are able to predict how firms will react to changes in prices of inputs or in the desired level of output. After deriving the intercepts and slope of an iso-cost line (see chapter two) and adding in

an isoquant, we are able to see the point of tangency between the two. This point of tangency will change as prices of either input change or when the desired level of output changes. This relates to investment in equipment and software because as the prices of inputs change, investment will change accordingly and affect the firm's behavior. By better understanding this relationship, we can better stimulate growth in our economy.

After evaluating the determinants of investment in equipment and software, I now have a better understanding of the relationships between all of the independent variables used in my study and my dependent variable. Upon running and analyzing a regression, I have found that four independent variables are significant; real manufacturing output during years of expansions and contractions, real wage growth during years of economic contraction, and productivity growth led 1 year ahead of years of economic expansion. This means that the behavior of investment in equipment and software is primarily explained by the behavior of these independent variables. Therefore, in order to best stimulate GDP growth to escape a recession, we should focus on increasing real manufacturing output, decreasing real wage growth, and increasing productivity growth.

It makes theoretical sense that real manufacturing output growth is positive during both years of economic expansion and economic contraction. Additionally it makes sense that real services output growth during years of economic recession would have a positive impact on investment in equipment and software. However, real services output growth during years of economic contraction should also have a positive impact on investment in equipment and software. But this value is very low so it is negligible. Alternatively, it makes theoretical sense that real wage growth during years of economic expansion and economic contraction would be negative. Paying workers more would definitely not have a positive impact on investment in

equipment and software because every dollar paid to the workers is a dollar not spent on investment in equipment and software. Similarly, productivity led by 1 year should have a positive impact on investment in equipment and software and indeed does. However, productivity the year before years of economic contraction should not have a negative impact on the dependent variable. Again, this impact is minimal and can therefore be neglected. Next, it does make theoretical sense that investment and equipment software the year before a recession would be much lower simply due to the fact that it is the year before an economic contraction occurs. Finally, the negative impact of the Great Moderation dummy variable on investment in equipment and software is to be expected. However, this coefficient that measures the impact of the independent variable on the dependent variable is small and can be neglected.

The overall fit of my model is represented by a fairly high R^2 value (.8984) which means that 89.84% of the variance of the investment in equipment and software growth rate from its mean is explained by the independent variables. This is a desirable outcome and means that I have successfully explained most of the behavior of investment in equipment and software by just a few influential independent variables. In retrospect, I realize that there are many factors that affect investment in equipment and software growth, but by using this small collection of independent variables I was able to provide a firm explanation for the behavior of investment in equipment and software growth.

Bibliography

Clark, Maurice J. Business Acceleration and the Law of Demand, *Journal of Political Economy,* March 1917.

Mitchell, Wesley C. Business Cycles, *Readings in Business Cycle Theory*, 1944.

Keynes, John Maynard. Notes on the Trade Cycle.

2013 Economic Report of the President.

Romer, C. (2008). Business Cycles. *Econlib.org.* Retrieved December 12, 2013, from http://www.econlib.org.

Davis, S. and Kahn, J. (2008). Interpreting the Great Moderation: Changes in the Volatility of Economic Activity at the Macro and Micro Levels. *Journal of Economic Perspectives, 22(4), 155-180.*

(October 2, 2006). Glossary E. *Bea.gov.* Retrieved October 28, 2013, from http://www.bea.gov.

Case, Karl E. and Fair, Ray C. *Principles of Economics.* Pearson Education, 2002. Print.

Besanko, David and Braeutigam, Ronald. *Microeconomics.* Wiley, 2004. Print.

"Economic Definition of Comparative Statics." *Economic Glossary.* 2008. Web. 5 Nov. 2013.

I created many Figures using Paint.

Valentino, Piana. "Isoquants and Isocosts." 2006. Web. 4 Nov. 2013.

Pearson. "Appendix: Isoquants and Isocosts." 2010. Web. 4 Nov. 2013.

Hall, R. and Lieberman, M. *Economics: Principles & Applications.* Cengage Learning, 2012. Print.

Piana, V. (2006). Isoquants and Isocosts. *Economicswebinstitute.org.* Retrieved November 5, 2013, from http://www.economicswebinstitute.org.

Clark, Todd and Nakata, Taisuke. "The Trend Growth Rate of Employment: Past, Present, and Future." *Economic Review* First Quarter 2006: 43-81. Print.



About the Author

Cameron Monroe Day III was born on October 17th, 1991 and raised in Huntersville, PA. Growing up he was a three sport athlete participating in football for 11 years, indoor track and field for 3 years, and outdoor track and field before carrying on to do track and field for another 4 years at Allegheny. His favorite activities back home include hiking, hunting, and fishing. He majored in economics and minored in mathematics at Allegheny College. He hopes to continue his active lifestyle and participating in athletics for many years to come.