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Competing Factors at Play: Understanding the Gap Between Innovation and Productivity

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ABSTRACT

This thesis will examine the gap between the increase in innovation and knowledge in the United States, and the declining economic growth rate the country has witnessed. It examines a book called *Knowledge and the Wealth of Nations*, which is centered around how the development of new products and ideas have been realized as factors which induce economic growth and productivity in a nation. It goes on to analyze current economic models used for growth such as the Solow growth model, and the key variables this model leverages. Once this has been established, the thesis continues to explain what the gap is specifically referring to, and how it has developed over the past 50 years. Next there is an analysis of what is causing this paradoxical gap between increased innovation and decreasing productivity levels. The factors outlined are the United States' decreasing population growth, economic misallocation, growing income inequality levels, a reduced level of value created by technology production in the United States, and the end of a wave of increasing returns resulting offshoring. The thesis then goes on to explain the predicted impact that AI will have on United State's productivity levels. Finally the potential impact of public policy is highlighted, as it explores how government bodies can impact the current levels of productivity. These factors are highlighted once more in the conclusion, which takes a broader look at these obstacles, and attempts to originate ways in which the United States can restructure its economy and policies to leverage this incredible access to innovation and knowledge and boost its economic growth rate.

TABLE OF CONTENTS

ABSTRACT.....	i
TABLE OF CONTENTS.....	ii
LIST OF FIGURES	iii
ACKNOWLEDGEMENTS.....	iv
Introduction.....	1
Defining Productivity.....	4
Technology Growth Correlates with Productivity Growth.....	7
<u>Knowledge and the Wealth of Nations: A Literary Review</u>	9
Current Economic Models and Innovation.....	17
Trying to Explain the Gap.....	24
A Declining U.S. Population	26
Misallocation of Companies in the United States.....	28
Income and Wealth Inequality in the United States.....	32
Diminishing Returns on Cycles of Production	35
AI and the Future of Innovation and Economic Growth In the U.S.	37
Public Policy’s Ability to Enhance U.S. Productivity:.....	39
Conclusion	42
Appendix.....	45
BIBLIOGRAPHY.....	46
FIGURE SOURCES:.....	51

LIST OF FIGURES

Figure 1- Country rankings in terms of innovation usage and production.	2
Figure 2 - Relative decline in real GDP compared to the increase in productivity/innovation.	3
Figure 3: An exponential growth in U.S. patents	6
Figure 4: The consistent overall rise in innovation and knowledge over the past decade.....	20
Figure 5: The exclusion of well-being in current economic models	23
Figure 6: The declining population growth rate in the U.S. over the past few decades	27
Figure 7: A steadily declining U.S. growth rate since 1985	34
Figure 8: Moore's law contributing to diminishing returns on U.S. tech manufacturing	36

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Introduction

As a Penn State business student looking to make an impact on this planet, I have long been fascinated by entrepreneurship and innovation. One day I aim to contribute to this world by finding a way create something new that boosts productivity. Whether it be through a physical invention, or the advancement of knowledge, I believe that innovation is one of the most impactful marks a person can leave on this plant. The advancement of goods and ideas is the driving force that has brought our society from cavemen gathering berries to engineers coding artificial intelligence software to teach itself. Since the beginning of humanity, innovation and the growth of knowledge has been the force that has allowed us to propel forward as a society. Among other important factors, innovation and knowledge are one of the main advantages that have allowed certain nations to enjoy periods of long-lasting economic growth. Innovation boosts productivity levels, which directly leads to economic growth. Therefore, a country that is constantly employing new methods, products, and knowledge should boast a growing economy right? This thesis will aim to answer if this is the case, and if not what is causing the paradox.

Society saw first-hand how innovation and economic growth can be directly correlated in the late 1800s with the American Industrial Revolution. During this period of rapid industrial change, automation advancements transformed America from being dependent on handmade goods and agriculture, to being a global leader in manufacturing. The advancement of methodologies, education, and invention carried the United States through a hundred year period of substantial economic growth. America was getting more production out of each individual worker than any other nation. However, after 1970, the United States economy has consistently seen a decline in its economic growth rate. This is certainly not for a lack of innovation. The

United States has consistently ranked in one of the top spots for innovation according to the Global Innovation Index Score.

Most innovative countries in 2023, by global innovation

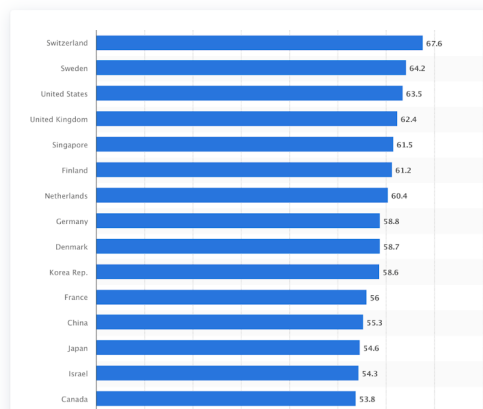


Figure 1- Country rankings in terms of innovation usage and production.

There is one, or likely several factors at play which are causing a gap between the United States' exceptional incorporation of innovation, and its diminishing economic growth rate. This thesis will aim to explain this gap by doing a deep dive into the theories of highly accredited economists. The results of this thesis will hopefully paint a clear picture of the forces in the United States which are preventing our innovation levels from catalyzing economic growth. From the identification of these factors, there will be a clearer sense of what to change. Some of the variables will be naturally occurring, while others will have potential solutions. By deciphering the obstacles to consistent economic growth in America, the potential solutions become more evident. This thesis itself is a direct demonstration of how advancing knowledge can contribute to improved productivity. The following will explain what productivity and innovation are, identify the forces that are working against them, and examine how the

relationship between innovation and productivity can change in the near future through forces such as public policy and artificial intelligence.

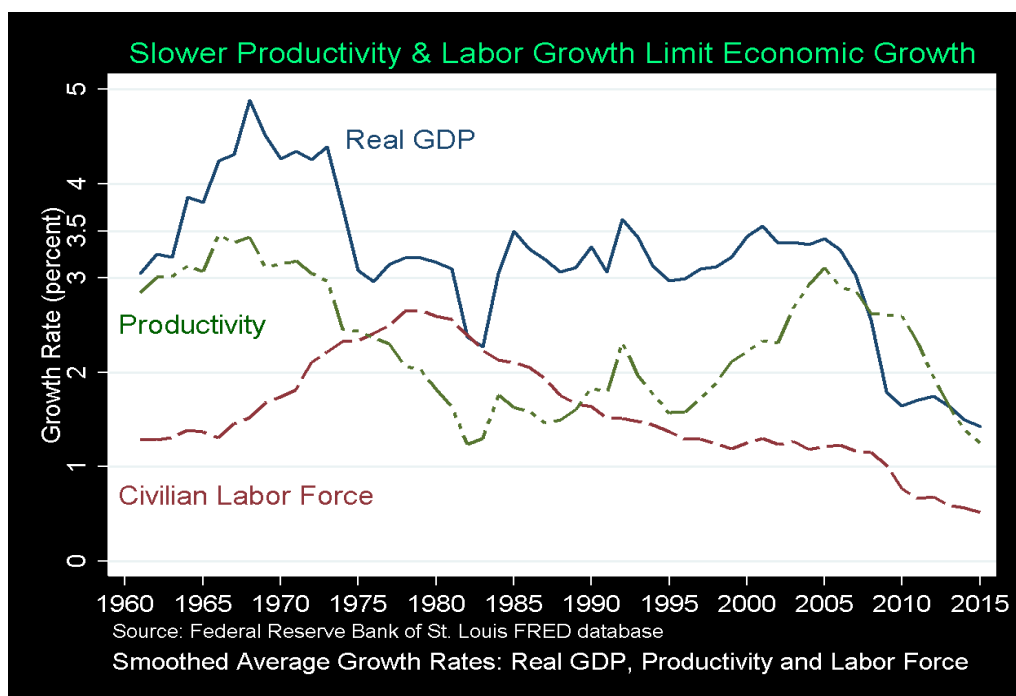


Figure 2 - Relative decline in real GDP compared to the increase in productivity/innovation.

Defining Productivity

To address the gap between rising levels of innovation, but decreasing levels of productivity, we must define what productivity is. Productivity describes the overall ability of a nation to turn factors of production into output. A nation with superior productivity will be able to produce more with the same amount of human capital than another nation. Productivity depends on the nation's ability to utilize their factors of production. Factors of production are the resources that are used to produce goods or services in an economy (Weil, 2009). Development accounting is a technique which measures the role of productivity in how a nation produces output. It analyzes what drives economic growth and income differences between various countries. It looks at factors like capital, labor force growth, and technological progression to measure how productive a nation is based off of its use of its use of the factors. Using development accounting, a nation's productivity can be measure can be measured by ratio, which states that the ratio of productivity is equal to the ratio of output per factor of production. If a country has a high ratio of output, it means that they are able to get a higher output from a set amount of factors of production than most others. Another important variable in a country's ability to produce output, is factor accumulation. Factor accumulation is the process of a nation increasing the quantity of inputs that it uses in production, such as physical capital, developing human capital, and natural resources (Weil, 2009). Factor accumulation is something that is leveraged by a nation alongside productivity, to produce their highest possible output. Wealthier more developed countries such as the United States, have higher factor accumulation than developing nations, such as Senegal. The United States has far superior access to advanced technology and a better education system, which allows them to develop a more skilled

workforce which makes up the human capital. Growth accounting is a concept, similar to development accounting, which aims to examine the impact that growth in productivity has on the income growth per capita in a nation. A figure developed by David Weil found that nations with the slowest growing income per capita have negative rates of productivity growth, whereas nations with the fastest, growing income per capita have the highest rate of productivity growth. A nation's factors of production also had a positive correlation to economic growth in these nations, however, productivity growth was a much more important variable in this growth.

Development and growth accounting showed that productivity growth rates are much higher in rich countries than poor countries. This demonstrates how vital a constantly growing productivity growth rate is to a nation's economic growth; much more so than its factors of production. Productivity growth and economic growth are directly correlated. with this being the case, it is alarming to see that the United States has seen recently a constant decrease in productivity growth per year. Overall, the slowing of productivity growth rate can explain why economic growth has been slowing down in the United States over the past decades. A paradox arises, because we are seeing a constant growth and innovation in recent United State's history.

The following figure portrays that the US has seen a constant and rapid growth in patents in the past 50 years.

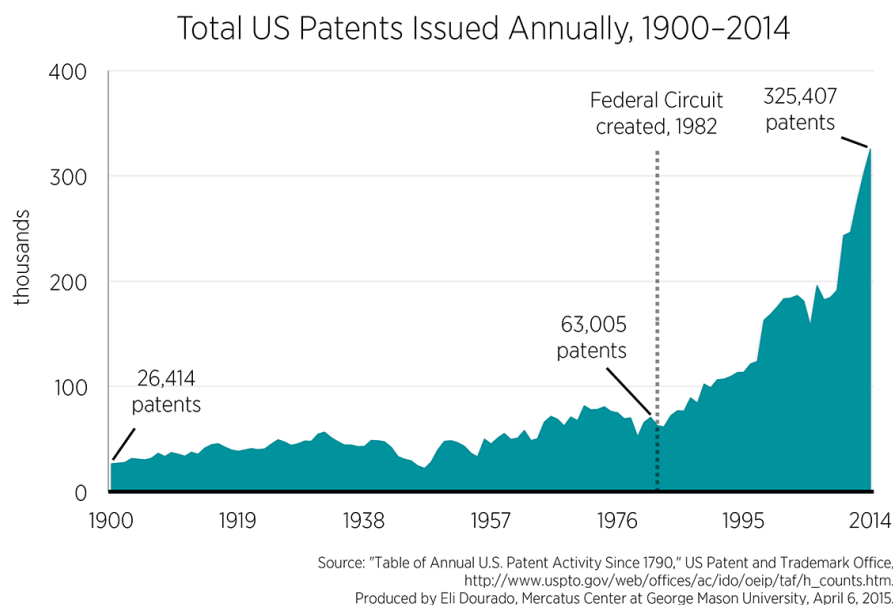


Figure 3: An exponential growth in U.S. patents

This means that there are more products and ideas that should be increasing the United State's ability to produce high levels of output by increasing productivity. It makes sense that by advancing knowledge and furthering the capabilities of technology, the ability of the United States' workforce to be more productive should also increase. However, we are simply not witnessing this expected correlation. Explaining this gap between innovation and productivity, could unlock key ideas behind why the United States has seen a prolonged decrease in economic growth rate. The United States already has a significant amount of factors of production with wide access to funding, human capital, and technology. It is the variable of productivity growth decline, which is likely the source of correlation to this economic growth decline.

Technology Growth Correlates with Productivity Growth

Productivity is significantly impacted by the advancements made in technology. The technological advancement of a coding software for example, can allow the same worker to produce at much higher levels, more efficiently with the same computer they had before. These advancements made in technology require significant investment from a nation. Currently, many nations invest a large percentage of their GDP to research and development processes in order to develop new products and knowledge which will help them be more efficient. The United States used about 2.8% of their GDP to put towards research and development of new products and ideas. Nations such as Japan devote even higher percentages of the GDP towards research and development. Japan spent 3.4% of its GDP on the research and development process (Weil, 2009). This significant research and development spending mostly comes from the private sector. Firms will engage in research and development in the attempts of advancing their current knowledge, or inventing something new that will allow them to boost their individual productivity. A firm will invest in research and development if they believe the new invention will give them a big advantage in the market, if the size of the market is worth it, and if the risk is worth what could be gained from the advancement. Hopefully the research and development process undertaken by these firms will replace old knowledge and production strategies with newer, more efficient methods. This process is referred to as creative destruction; a concept which will be further explored in this thesis.

A mathematical model created and run by Paul Romer found that increasing spending and resources on research and development lowers output in the short run but will raise it in the long run. When he applied this model to the world as a whole, he found that increased spending

on research and development will increase both the country's income and position in the global technological hierarchy. He also found that in time this technological growth for that country will increase the growth in technology development for the rest of the world. Growth in one country's technology will trickle down and benefit the other nations of the world (Romer, Mankiw, Weil, 1992).

A major advantage of a non-physical tool, such as technology is that its use is non-rival, as compared to a physical piece of equipment such as a hammer. Non-rival means that technology being used by one person, does not prevent another person from using that same technology. This is one of the many advantages of technological advancement, is that it can be used and transferred throughout a country without taking away from the side that is sharing it. In contrast, a physical advancement, such as a power drill cannot be shared as easily, and it take this tool away from the other side. This nonphysical advantage of technology allows for productivity to grow much faster (Weil, 2009). The role of advancing technology is a key instrument in the continual growth of an economy. The growth of technology is dependent on investment in time, money, and human capital. Therefore, these factors are solid indicators of a nation's potential for productivity growth to occur within its borders.

Knowledge and the Wealth of Nations: A Literary Review

To begin exploring the current state of the relationship between innovation and entrepreneurship, I examined numerous articles, books, and websites on the topic. Of these sources, one book stood out which began my learning and understanding of this topic: Knowledge and the Wealth of Nations, by David Warsh. This book did an excellent job at explaining economic advancements in understanding over time, what an economic model is, variables that have gone into building economic models and how they have evolved with time, and finally addressing the unavoidable misrepresentation of innovation in these economic models. It discusses the progression of human understanding of how economies grow and their impact on all levels of our society. This section of the paper will further explain the knowledge I obtained on each of these topics from David Warsh's Knowledge and the Wealth of Nations, and several other key literary sources.

First, we will examine the main economic advancements and theories that have shaped our understanding of how economics functions and grows. This book acts as an extension to the ideas of famous economist Adam Smith's popular book, *The Wealth of Nations*, written in 1776. David Warsh's book was written in 2006 and fills in important advancements in understanding that have been made since 1776. Smith was ahead of his time in the field of economics, and in many ways completely redefined the entire way in which we view economics. He argued that the way a nation's economic status is viewed should not just be exclusively contingent on the amount of gold and silver which they possess but extend to examine that nation's standard of living and ability for growth. At the time Adam Smith was writing *The Wealth of Nations*, important variables such as personal wealth, health, and availability of goods

and services were not considered when examining a nation's economic status. The entire view of economics began to shift after Smith shared his ideas. This was extremely monumental to our society, because it spurred the idea that we must constantly be improving and building upon our understanding of what economics measures, and what defines it. David Warsh's book Knowledge and Wealth of Nations goes on to explain the many additions to economic understanding by important economists which have occurred since Adam Smith's book. Before addressing these later additions to economics, it is vital to this thesis to examine Adam Smith's individual contributions to how we understand what economics actually measures.

Warsh goes into great depth discussing two important ideas from Smith's book: the invisible hand, and the pin factory concept. The invisible hand is an important economic concept, in which the "invisible hand" denotes the self-interest of human beings, and how this self-interest leads to economic and societal advancement. Warsh explains how this is one of many invisible forces which leads to the growth of an economy. People act in their own self-interest by innovating and inventing new and better ways to do something. These advancements made by many self-interested individuals ultimately come together to make our economy and society more efficient with their advancements. An important concept associated with the concept of the invisible hand, is another concept Smith helped create called laissez-faire, which is a French term advocating for less government interference in the economic activity of the citizens under them. This freedom from government interference is vital, because people have more liberty to pursue ideas, and more motivation because they can receive compensation for their ideas which progress society. The lack of governmental interference in innovation is another important variable highlighted by Smith which contributes to a nation's economic standing. Countries with more

freedom will naturally be more motivated to improve upon current processes and products, which in the long run has a major beneficial impact on the economic status and growth of a nation.

The other important economic concept from Smith which Warsh explains is the pin factory metaphor. He explains this as a way to highlight how specialization/division of labor advance society and the economy. If everyone at the factory is doing the same job the work will get done, but it will take a while. However, if everyone at the factory has their own specific job, they will become quicker and better at it than an inexperienced person. This is the definition of specialization. People can focus more on their specific function, which will allow them to build important skills and make advances in ways to do these roles better. The pin factory metaphor and the invisible hand concept are two vital economic concepts which directly highlight how innovation impacts economic advancement, a theme which this thesis will revolve around.

After insightfully describing the ideologies and advancements in thinking made by Adam Smith, David Warsh goes on to deliver chronological stories from other important economic theorists. These theorists advance and support the views of Adam Smith, all essentially arguing for an increasingly abstract, less black and white view at how economic growth occurs and how to make models in order to track it. A key economic thinker whose ideas influenced the direction of this thesis is Kindleberger, who advocated for an expansion of the economic models of his time, which were largely math based. Kindleberger is renowned by many of the economists in the field as a master of economics, and as one of the most influential economic theorists ever. In addition to writing over 30 books on his views about economic theory and progression, he worked on one of the most important economic projects in the past decade.

Kindleberger as a key leader in the development of the Marshall Plan, which was essentially the plan for how to repair the very damaged economic, political, and physical integrity of Western Europe in the aftermath of WW2 (Altman, 2003). To be a leader in such a monumental economic plan which saved several U.S. allies from collapse is an exceptional distinction from others in his field. It backs his theories with an undeniable background of success and demonstrated intelligence in economics. Among several other important economic theories which are less relevant to this thesis, a main argument of Kindleberger's was that the economic models of his time needed to be expanded upon in order to capture the entirety of the situation, not only the numbers behind the trends we witness (Warsh, 2007).

Kindleberger was a theorist who was the most prominent in his field during the middle and second half of the 1900s. During this time economic models which depicted the current economic status and growth predictions of a nation were largely predicated on calculating numbers, ratios, and percentages. They tracked simple economic variables which could be quantified, such as price fluctuations, inflation rates, and interest rates. These models failed to incorporate other, less tangible factors into their reasoning. Several of these less tangible factors which Kindleberger advocated for were the incorporation of investment, technological advancement, and innovation into the models as variables that lead to sustained long term growth. He knew that although it was difficult to assign a number to these factors, their impacts were substantial and could not be neglected. One shortcoming of Kindleberger's which is evident from Warsh's book, is that he did not get a very specific method down for how to measure this innovation. This is an extremely complicated task however, which still hasn't been fully tackled today. Had there been a current, perfect method for measuring innovation's impact on economic

advancement, then this thesis would not need to be written. However, Kindleberger still had a crucial impact on the field of economics during his time in the field, and his advocacy for the expansion of economic models to include factors such as innovation paved the road for many other economists to build off.

Another very influential economist advocating for the significance of innovation and entrepreneurship in economic growth is Joseph Schumpeter. He made his largest contributions to the field of economics in the former half of the 19th century, and likely influenced much of Kindleberger's theories and contributions. This Austrian born economist focused on the fields of entrepreneurship, business cycles, and innovation. One of his greatest advancements to the field of economics was his idea of "creative destruction". This theory basically states that when an individual or company makes an advancement, it destroys established industries but also leads to the creation of new industries. He argued that this was essential for a nation's economic growth and progression (Warsh, 2007). A prime example of this is the invention of cars. Before cars were an everyday commodity, people would use horse buggies to travel medium amounts of distance. However, when cars became popular and affordable, it completely replaced the industry of horse-drawn wagons. While destroying one industry, this invention also created a larger and more efficient industry. The creation of this new industry directly led to economic growth because of the exponentially increased ability for people, goods, and information to spread throughout the United States. "Creative destruction" is a concept which Schumpeter believes is vital to economic change. He is effectively arguing that innovation is a key driving factor in how a nation's economy can grow; through advancements being made which allow capital to be raised via more efficient and less expensive methods. "Creative destruction" is

essentially one of many beneficial impacts of innovation. Shumpeter is an economist who, like many others in the book Knowledge and Wealth of Nations, believes that innovation is a key instrument in economic growth, and knows that it must be accounted for in future economic growth models. His organic ideas on business cycles and creative destruction further demonstrated to society how impactful innovation and knowledge are to an economy.

A concept defined and explored in Knowledge and Wealth of Nations is endogenous economic factors, which contrarily to exogenous factors refer to an internal impact. Perhaps the single most influential piece of writing discussed by Warsh in his book is Paul Romer's paper from 1990 titled, Endogenous Technological Change. In this paper, Romer advocated for his economic views. He was a patron of the importance endogenous factors being included in models, and the concept of increasing returns to scale. The concept of increasing returns to scale states that unlike physical capital, advancing ideas and knowledge should create increasing returns (Romer, 1990). It makes sense to assume that by advancing knowledge in an industry, this industry should be able to increase at higher efficiency as a result of this newfound information. This theory however has not been reflected in reality, as we are constantly increasing our knowledge in the United States, however we still experience diminishing returns which has hurt our economic growth. This paradox is in large part what this thesis aims to understand.

Romer developed a model which differed from traditional models of the time. His model was the first to include endogenous factors inside the model, such as increases in research and development investments, changes in knowledge, and innovation levels. Previously economic

models used to ignore the impact that internal variables within a company or nation could have on an economy. They strictly looked at the quantitative and qualitative relationships between different economic values. As Kindleberger previously put it, the models were extremely mathematical and relied mostly on exogenous factors. The point that Romer was attempting to portray in his paper is that these models needed to shift over time to consider the obvious and crucial impact of endogenous factors in economic growth and decline. Innovation within a nation is a prime example of an endogenous economic factor, because it is happening internally within the walls of a company or country. A great way to understand the combined impact of both endogenous and exogenous factors is to look at one company and its growth over time. This company will be impacted by many exogenous factors such as governmental policies or a change in the international value of the dollar. However, the growth and performance of this company is also significantly impacted by endogenous factors such as excellent managerial practices or company innovation. If a company finds a way to innovate its production process by using automated machines rather than human labor, they will increase margins significantly while also being able to produce goods at a higher rate than previously. This endogenous factor leads to a substantial increase in this company's growth. In fact the impact of innovation in this example is equal to if not greater than the impact of the exogenous factors at play. This is why Knowledge and Wealth of Nations repeatedly stresses the realization over time that innovation needs to be present in any model that measures economies and their growth over time.

The economists focused on in this book each played an important role in arriving at this conclusion. They each identified new impacts of innovation on an economy until it became quite clear that any model ignoring innovation is only examining a portion of the variables at play.

Thanks to the efforts of these economists it is now accepted that innovation must be a considered factor, however this has proven to be easier said than done. The beauty of the primitive economic models was that they relied on tangible figures which could be measured, calculated, and compared. Endogenous factors such as innovation are not tangible; they cannot be calculated by pulling and manipulating data. Additionally, there is no rule book that shares insight into how much to weigh each variable. Innovation obviously has its importance, but it becomes unclear how to weigh alongside other, tangible factors which are also extremely important such as inflation rates and national GDP. Knowledge and Wealth of Nations goes into great detail on how knowledge and innovation gained the recognition they deserve, however the technicalities of how to measure this new endogenous factor become numerable and subjective.

Current Economic Models and Innovation

An important step in understanding how we should measure the impact of innovation is to get a holistic view of what current economic models look like. There are several commonly accepted economic models measuring growth and variables which directly contribute growth. According to the International Monetary Fund (IMF) there are two main types of models: exogenous growth models and endogenous models. Both kinds are important, and there is a lot we can learn and predict by using them. They each identify different drivers of economic growth in an economy. One is not inherently better than the other, because both work together to tell the overarching story of what drives this growth. Exogenous models look at factors that are external to the model. Exogenous models look at variables such as technological growth or labor force changes which occur independently from the actions of an economy. This type of model examines how variables that are independent from the economy affects its growth or lack thereof. Contrastingly, endogenous growth models examine variables that occur within the economy itself. They could be factors such as government policies or household trends. Exogenous models suggest that growth in technological capability is the main driver of economic growth. On the other hand, endogenous models suggest that economic growth stems from capital investment in research and development which lead to innovation, and from factors that impact capital efficiency. For example, inflation, government policy, and interest rates impact a nation's capital efficiency (Odhiambo, Chirwa, 2018). At this point a consensus has not been reached on which of these predictions is more accurate than the other. Both of these models are correct in identifying their own portion of the entire story. The key point of these models pertaining to this thesis is that both models identify innovation as being a main driver in economic growth.

Innovation and knowledge advancements can stem from both internal and external economic factors.

The most common model relating to what drives economic growth in a country is the Solow growth model named after famous economist Robert Solow. As the name suggests, this model measures and attempts to explain long-term growth in a nation by examining several variables: capital accumulation, population growth, and technological progress (innovation) (Weil, David, et al, 1992). These three variables are very important to addressing this thesis topic and will be individually examined later in this this paper. The model advocates that the contributions of technological advancement are more impactful to economic growth than capital accumulation. The Solow growth model is an exogenous model, which means that the variables it examines or exogenous, or outside of the model. They naturally change and vary from forces in society, not from within the model. Exogenous models will be further explained in the next paragraph. Each of the three variables has its own independent fluctuations, and these fluctuations affect the result which is total economic growth. The first is that the higher the amount of saving and capital accumulation, the healthier the levels of income and economic growth will be in that country. This is because the nation has more resources to use, and more capital to invest in new technological investments used for output. The second is that a high population growth will make the country poorer. However, it is beneficial for economic growth in a nation because it allows for a larger workforce, and more people can be put towards research and development projects which result in increased innovation and ideas, which in turn boosts a nation's economic growth. The final variable is technological advancements. This variable represents the focus of the thesis which is advancements made in knowledge and inventions.

Naturally it makes sense that as technological advancements improve within a country, so will the productivity of that nation. The human capital in a nation has more efficient tools and more advanced knowledge to use while they are working, and therefore productivity level increase (Weil, David, et al, 1992). Having established that the Solow growth model examines how human capital, capital accumulation, and technological advancements equal the total output and growth levels of a country, this thesis will examine their relationship and look specifically at the future and current state of technology in the United States.

Once innovation has been categorized, the next step is to collect the actual data itself. This is done in several ways. The first is by conducting a census in which surveys are sent out to companies which gather previously private information about the financial and non-financial impact of innovation. Another method for collecting data on the impact of innovation on the economy is examining company filings and reports, which among other subjects discuss innovative activities within that company and their outcomes. Examining patents is an additional way which economists can measure rises and decreases in innovation levels of a country. If each year the growth rate of numbers of patents is growing, then it is deductible that overall innovation is growing in that country. Patents represent an idea or invention which boosts a firm's productivity level. Therefore if a country has a growing rate of patents year over year, then innovation levels are increasing in that country (Weil, 2009).

Through these methods innovation has been accurately measured over the past several decades. Statistical data on innovation has depicted a constant increase since the early 1900s. Advancements such as transportation improvements, increased healthcare capabilities, greatly

improved communication methods, and the invention of the internet have maintained the upward trajectory of the impact of innovation over time (National Academic Press,1997). These advancements increase business capabilities, quality and duration of life, individual worker efficiency, and more. However, these measurements are paradoxical and contradictory when compared to the corresponding economic growth rates of nations. We don't see economic growth across the board in countries where there has been constant innovation and improvement. This means that there must be some sort of problem with current economic models.

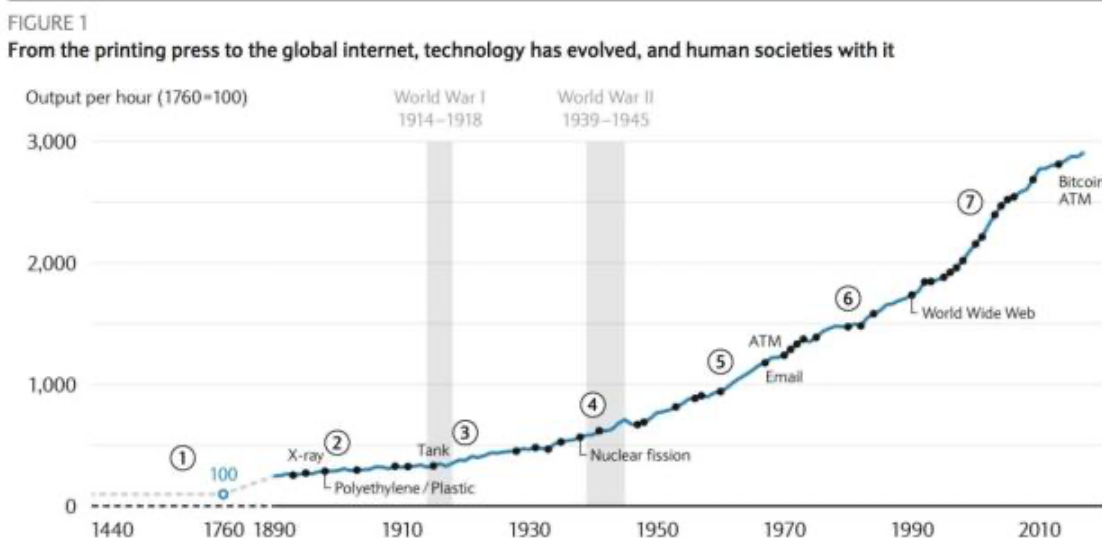


Figure 4: The consistent overall rise in innovation and knowledge over the past decade

Although there are many things economic models are currently doing well, there are several major issues with the models which are currently used. They are overestimating the impact of certain variables, while underestimating the impact of others. The first major issue with current models is overestimating the productivity of worker. Many times, employees at company are paid an amount that is unequivocal to their actual levels of productivity. Workers earn what they are able to negotiate depending on the current health and status of their company,

not the exact amount of value and productivity they bring to said company. Current economic models value higher worker's salaries as something that is a reflection of economic productivity, however it is not. Higher employee salaries may actually be a cause of productivity, which contrasts with current economic models which measure this variable as a result instead (Hanauer, 2023).

Another key issue with current economic models is that they underestimate the productivity and benefit from investing lower class citizens and assume that immigrants are not as productive as domestic workers. As this thesis will go on to share, public investment in skilled immigrant workers is one of if not the easiest and most efficient way to boost the productivity of the American workforce. The current models assume that government investment in lower class housing and food security plans will decrease overall productivity. The idea is that by subsidizing life for lower class citizens it is money taken away from productive members of society, and money put towards encouraging laziness (low class citizens ability to participate in society) (Hanauer, 2023). Economic models are also completely incorrect in assuming that immigrant workers are less productive than American workers. It is the opposite of the truth; although many immigrant workers do get paid less, they increase the United States workforce and boost America's productivity. This means that economic models are currently underestimating our total productivity levels by severely underestimating the impact that investment in lower class cities and immigrant workers has on our productivity levels. Our view of productivity itself is flawed in large part due to the fact that key drivers of productivity are being undervalued.

A final substantial issue with the current economic models used in the United States is that they measure strictly GDP and revenue growth and exclude the well-being of the citizens and domestic society. Economic growth leads to an overall increase in well-being for the nation it occurs in. It leads to higher wages, which leads to more money circulating around the economy, which leads to improved business performance. However, the model excludes the results beyond the immediate. Valuable societal factors such as education, healthcare, wellbeing, and the environment are completely ignored. While monetary gain is measured, the potential side effects of these gains go under the radar (Hanauer, 2023). An example of this would be the rapid growth of factories in America. These factories can produce great revenues and wages for the employees that work there, however they also have negative side effects which are meetly ignored by economic models. With more factories comes a great deal more of harmful emissions being released into our atmosphere. The environmental impact of this will contribute to pre-existing environmental problems which in the long run can completely outweigh the short-term benefits brought about by these factories. Another negative side effect could be poor working

conditions for employees, and this could lead to a more accepted view of how workers can be treated; a situation which is very difficult to reverse.

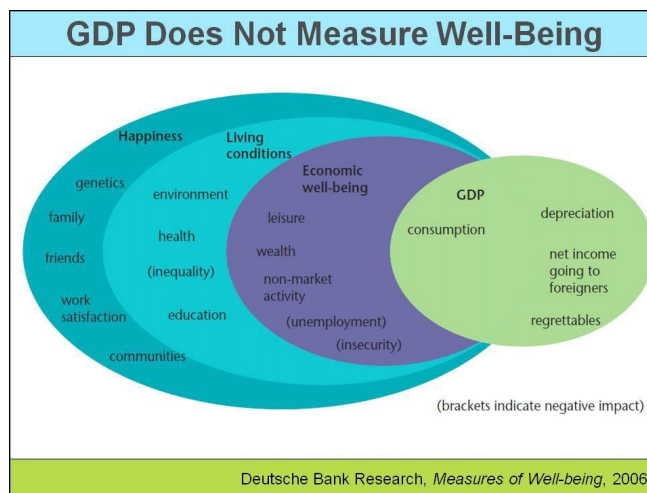


Figure 5: The exclusion of well-being in current economic models

These are a few of the main institutional errors with how economic models are measuring the health and predictions of economic output in the United States. Our view of productivity and innovation is incorrect because they are being measured only partially. This contributes to the thesis by demonstrating that our view of innovation and productivity and how they contribute to economic growth is incomplete. These variables are not being measured in their entirety. Only certain benefits of these variables are being measured and recorded, while other important parts are emitted. This shows that our very sense of economic growth is only a piece of the entire story. Therefore it is not our government and society that is fully to blame for this gap between innovation and economic growth, but also the fact that their correspondence is being inaccurately measured right now by the economic models we have.

Trying to Explain the Gap

The United States is a country that in the past century has been responsible for fostering a great deal of innovation and adopting foreign advancements that have been made. With the United States consistent exposure to such a magnitude of new ideas, processes, and inventions it would be logical to conclude that the country would experience constant economic growth. However, the United States economic growth rate actually slowed from 2006-2016 to half of what it had been in the previous 40 years (Gordon, 2018). It is counter-intuitive that a nation that incorporates the internet, robotics and animation, and constant improvements to efficient-boosting technology would not see constant growth in their economic output. How could a nation see slower economic growth rates after implementing tools like the internet and 4G wireless connection, which boost the productivity of every member of the workforce? Answering this question requires a holistic view of economic factors across the board in America. There are many variables in play when it comes to a country's ability to maintain significant economic improvement. My hypothesis for this gap between innovation and economic growth is that several major variables are at play which are working against the direction that innovation and knowledge have been. It is comparable to a person trying to build muscle mass by consistently exercising but ignoring other important required parts of this process. By going to a gym and exercising every day, it would only make sense that that person will become healthier and see physical improvements. However, if this person also has a consistently poor diet and does not get enough sleep every night, these variables will prevent this person from achieving the progress that would be expected.

In the case of the American economy, I predict that although there has been significant growth in innovation and knowledge available, several key factors are outweighing our advancements and slowing the economic growth rate. I will test this hypothesis and ultimately answer this question by examining a cumulation of sources. I will then report on the most significant findings from these sources and give a research-backed, holistic view of why this paradox has occurred consistently since the 1970s.

A Declining U.S. Population

Over the past several decades the United States has experienced a general downward trend in its population growth rate. Families have been having a smaller amount of children in each proceeding generation. This referred to as the United States' fertility rate, and because women are having less children, the fertility rate in America has been decreasing. Economic growth is dependent on available human capital, and productivity levels in that nation. As society continually advances new, productivity boosting ideas and knowledge become harder and harder to find. Periods of rapid industrialization and technological advancement such as the industrial revolution and rapid advancement of the internet jolted our economy forward, however at this point new ideas are more elusive. Therefor it requires a greater allocation of the population working towards producing and developing new ideas which will boost levels of United States productivity (Weil, 2009). A certain portion of the United States workforce needs to be in labor positions such as construction, banking, and management in order to maintain the current production levels of the United States economy. However, if the United States want to see its economic growth rate rise again it needs to start designating a larger percentage of its population to the development of new ideas and knowledge because this will directly raise our productivity levels. Unfortunately, the consistently declining United States population growth rate makes it difficult to allocate more people to the development of new ideas and innovations. Population and productivity are correlated, and their combined levels directly impact the economic growth rates we experience as a country.

Declining population growth rates in America is a force that works directly against the positive impacts made by increased innovations and knowledge in the United States.

Productivity levels can only grow so much from one new invention or idea before they begin to plateau. For economic growth to grow constantly the United States needs to continually be making advancements and finding better methodologies for increasing output. In other words complacency leads to economic growth rates declining. It is the role of the United States population collectively to innovate and develop new ideas, because these advancements lead to productivity growth, and ultimately economic growth. The declining population growth rate is a significant obstacle to our ability to do this. A solution to this problem we face is to boost America's attraction to skilled immigrant workers. This method will be further explored later in thesis, but in short it is the cheapest and most efficient way to restore losses in population and add valuable, skilled people to our workforce. The addition of skilled, immigrant workers will ultimately contribute to the amount of advancements and ideas the United States is able to produce (Hanauer, 2023).

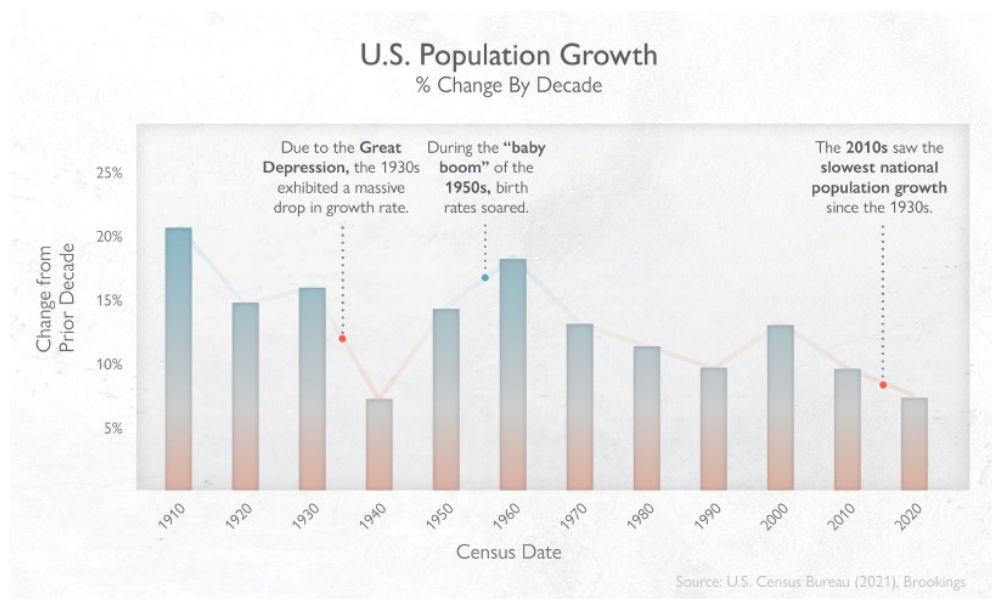


Figure 6: The declining population growth rate in the U.S. over the past few decades

Misallocation of Companies in the United States

Misallocation is a prime example of an inefficiency in the American economy which significantly obstructs the advancement of our productivity levels. Efficiency measures how effectively, a nation can leverage its technology and factors of production, to create levels of output. Misallocation is the term used to describe the miss use of resources by a nation, which brings their productivity levels down from what they could be. Not putting all resources towards the most efficient means to economic growth is misallocation, and it is certainly present within our economy (Weil, 2009). A good representation of this allocation issue in the United States is for example if a small, young, startup company was more innovative and productive than big companies in its market, but because of funding issues they were out competed. This startup should theoretically be funded and supported by the United States economy because it would do much more for our productivity levels than the big companies that are complacent where they are. However, due to current inefficiencies the startup is outcompeted and its potential positive contributions to productivity are diminished. This example happens often in real life. New, better firms are unable to replace older less productive firms because of frictions that prevent efficiency. If every potential variable to maximize our productivity levels were being implemented to their full extent into the American economy, then we would likely see productivity growth rate levels increasing each year rather than decreasing. There are several different areas where misallocation can arise from, the first of which is financial friction.

Financial friction occurs when financial factors disrupt the most productive and innovative firms from being able to grow and continue to contribute to the overall productivity levels of the United States (Buera, Kaboski, Shin, 2018). An example of a financial factor getting

in the way of a startups ability to grow is that it may be harder for these companies to find funding. Startups have a lot of initial, upfront costs which can be expensive and cause a smaller firm to be reliant on loans in order to fund their growth. It is a big risk to provide a loan to a young company that has not demonstrated its ability to grow long-term, whereas investing in a large company that has been around for a while such a Walmart is a much safer bet. This benefits banks and other investment firms in the short run because they are able to reduce their risk, but it hurts the overall United States economy in the long run because less of these innovative startups are able to receive the funding needed to grow and continue contributing to our overall productivity levels. Another key contributor to financial friction is **markup dispersion**, which is essentially the variation in markup percentages for firm's profits between industries. These markups can distort the labor supply and inputs a firm relies on to thrive. An increase in inconsistent markups is tied to the declining percentage of income that goes to workers in the United States (Autor, D. Dorn, L. Katz, C. Patterson, and J. Van Reenen, 2017).

The next form of friction preventing blocking optimal efficiency is monopoly interference with innovative startups functioning as they should. A company will make a few key advancements and innovations which they patent at an early point in their existence, and this early advantage will give them the ability to form a monopoly-like dominance in their industry. Once this firm has expanded and accumulated a substantial amount of wealth, it will have the ability to acquire any startups in its industry that it sees as a threat. This is harmful for two reasons. The first is that the large company no longer needs to prioritize innovation and creating new ideas, because it can just acquire any company that has made these progressions. The other is that these small startups that need to innovate in order to survive will stop innovating once

they are acquired. They do not survive long enough to reach the point of IPO. This trend has greatly interfered with the concept explained earlier in this thesis of creative destruction; a force Schumpeter said was an essential part of economic growth and progression. Younger and better firms are unable to replace older less innovative firms because their wealth and power blocks them from evolving to the point of competition. An example of this is Walmart, which found a way to differentiate itself from other grocery stores in the form of price point advantage. This differentiation allowed them to grow into becoming the world's largest food and merchandising retailer. Sam's Club found a new way to differentiate itself and compete with Walmart through their membership strategy which increases consumer loyalty. Walmart had the size and resources to address this new competition by simply acquiring it. Now that Sam's Club is owned by Walmart, the people inventing new ideas no longer need to, so the lines of innovation stemming from Sam's Club have significantly slowed. Through monopolistic interference, creative destruction has been significantly halted, and efficiency is not achieved due to this friction.

A final form of friction which prevents efficiency is hiring and firing friction within firms. Under completely efficient circumstances, the most qualified workers would fill the role that they are the best possible fit for. If this were the case, each firm would be able to operate at a higher level, and be able to create new ideas and products that boost efficiency because the workers at the company understand the industry and have the skillset required to make these advancements (Hsieh, Klenow, 2012). Obviously labor market efficiency is not possible, and many times the opposite is true. There are many obstacles that get in the way of the perfect candidate for a position not being in that role. An example of hiring friction preventing labor market efficiency is a company not being able to fill vacant roles with qualified employee

candidates due to the time consuming and labor intensive process of recruitment. If companies across America are constantly unable to fill their positions with qualified, target candidates that it will lead to the underutilization of human capital, which ultimately leads to productivity losses. Firing friction has a similar affect, as legal and regulatory restrictions are examples of obstacles which prevent the relocation of employees from less productive to more productive positions. Human capital is one of the main driving factors in the status of productivity in a nation. If a nation has a high percentage of employees in skilled positions which their education and experience best match, then naturally the productivity of that nation will go up because the work force is producing more output, and better adept at innovating to propel their firm forward. This is why hiring and firing friction are two obstacles which currently are impeding the ability of our nation to experience growing productivity rates.

Income and Wealth Inequality in the United States

A socioeconomic trend that has also dampened the effects of innovation is the consistent increase in income inequality over the past 40 years. “Income inequality has increased by 40% from 1980 to 2021” (U.S. Department of Commerce Staff, 2023). This income inequality has a detrimental effect on the United States’ economic growth capabilities, and directly lessens the impact of innovation. With a high level of income inequality, access to resources and education becomes greatly unbalanced. This resource inequality is another factor which negatively affects the human capital with which the United States relies on to fill its roles (Zeira, Galor, 1993). There are several explanations for why the United States has a peculiarly high income and wealth inequality for a rich country. The first of which is the technological advancements made in the past 30 years. The addition of computers and new software complements the skills that educated people already have, therefore widening the gap in productivity between them and uneducated workers. The increase in prevalence of international trade is another factor which has increased the wealth and income inequality in the United States. International trade benefits United States citizens differently. For example, citizens living in coastal areas near ports will benefit more financially from this trade than citizens living inland (Weil, 2009).

This income and wealth inequality is beneficial in terms of physical capital, but harmful for human capital. The inequality is good for the accumulation of physical capital for a nation, because individuals on the higher end of this gap have more wealth to invest on physical capital which can help their firm’s productivity (Weil, 2009). For example, a woman who owns a glass production factory can use her wealth to invest in physical capital such as an automation machine. This will boost the productivity of her company, and marginally overall productivity in

the United States. On the other hand, this wealth and income inequality is harmful for human capital for several reasons. One of the most obvious and impactful is that people on the lower end of the spectrum face limited access to education and healthcare. A family with relatively low income does not have the resources to put their children in private school, or provide them with tutors. This is especially harmful because STEM subjects in school often lead to positions after school that focus on research and development, which leads to new inventions and knowledge development. With less qualified and skillful students entering the workforce our overall human capital is weakened, as is the number of people able to work on making advancements in productivity.

Income Inequality is something that has historically been a fierce opponent to economic growth. For example the Gilded Age in America, which occurred from 1870 to the late 1890s was a time of extreme wealth inequality for United States citizens. At this time the upper class was in a position to leverage their position to gain power and increase their wealth, while the lower class fell victim to this power disparity and fell into extreme poverty. Due to this imbalance in status and socioeconomic status, less people were able to get themselves into a position where they could make significant contributions to the economy or drive innovation (Probasco, 2023). When the Gilded Age ended, economic growth began to soar, because America was overtaken by a period of rapid innovation and better knowledge about how to produce goods. This period is referred to as the American Industrial Revolution. During this revolution, the income gap decreased and more people were able to boost U.S. production and earn money, thus facilitating the economy. Now over 100 years later we have fallen back into a time of consistent income inequality, a variable which mutes the impact of innovation, and the

rate at which the United States economy is able to grow. In fact the United States has witnessed its economic growth rate decline consistently over the past few decades as shown in the following figure:

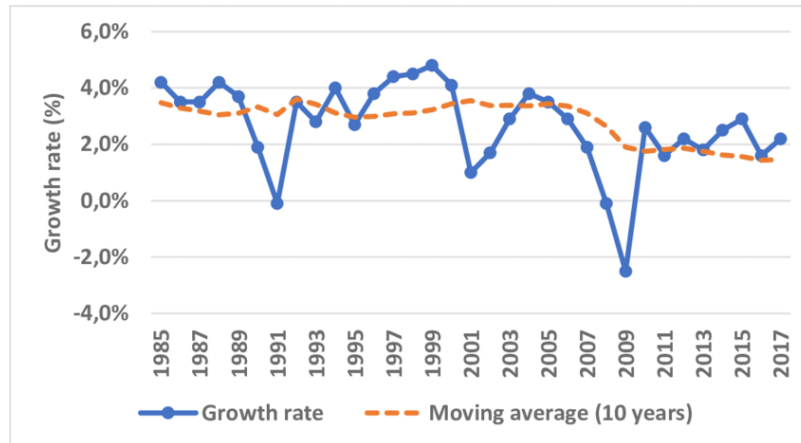


Figure 7: A steadily declining U.S. growth rate since 1985

Diminishing Returns on Cycles of Production

Shifting to a different sector that is disrupting the relationship between innovation and productivity; the United States is currently experiencing a period of diminishing returns on manufacturing output. The majority of manufacturing sectors have decreased in their levels of productivity since the 1990s, however it is the electronics sector that has been negatively impacted the greatest (Mischke, Jan, et al, 2024). This is due to Moore's Law, which states that the number of transistors in a micro-chip will double each year, which increases the ability to compute at a lower cost and size of the device. Essentially the amount of traceable value added with each improvement in a technological device has been decreasing since its peak in the late 1990s. In the United States the productivity growth regarding electronics manufacturing fell from about 24% to 5%. This represents 40% of America's decrease in manufacturing productivity, and 20% of the total economy decline (Mischke, Jan, et al, 2024).

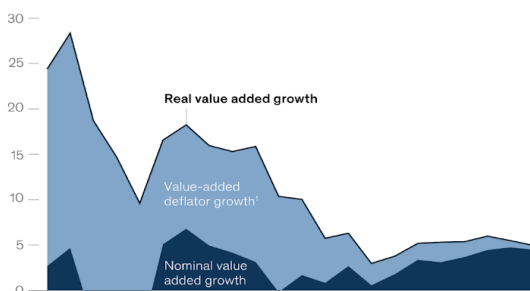
A similar reason we have seen a decline in the United States' economic growth is that a very profitable and effective wave of offshoring has slowed its productivity levels naturally throughout time. Many of the world's leading manufacturing nations began offshoring in the late 1990s, which for a long time boosted the productivity per worker and dollar invested. However, after this period of restructuring ended, the number of hours worked at manufacturing sites began to grow again. This in turn reduced the productivity from manufacturing activities to more normal levels. We experienced rapid productivity growth during this wave of offshoring and restructuring, however now that this wave has come back down to more normal levels, the growth in productivity has greatly slowed (Mischke, Jan, et al, 2024). It is conceptually confusing because hearing that the United State's economy is growing at a slower rate makes it

seem like every contributing factor is something negative that happened, but it is naturally occurring in this case that the amount of profit and growth realized from offshoring must plateau due to natural economic cycles.

Both of these two decreases in productivity due to time can be summarized by the law of diminishing returns. This law essentially states that the amount of returns and value realized from a new expenditure will reach a peak, and then begin to fall gradually. This is due to the fact that there are fixed factors such as the amount of equipment or land available for a manufacturing company, however variable costs can increase over time although your output has peaked and remained constant. We are seeing this in both cases mentioned above. Moore's Law explains how the amount of value added to the U.S. economy from each additional technological advancement reaches a peak, and after this peak we experience less value gained from each new piece of technology. In the other case of the offshoring wave coming to an end, the U.S. saw rapid economic growth from the idea to manufacture offshore, however after this new wave of production had been in practice for a while it naturally could not maintain such rapid levels of productivity per dollar invested (Mischke, Jan, et al, 2024).

Moore's law is producing diminishing returns in US computer and electronics manufacturing.

US rate of quality improvement in computers and electronics, growth in real value added and nominal value added, 3-year rolling average, 1997–2018, %



Computer and electronics manufacturing productivity growth, CAGR, 1997–2007 and 2012–19, %

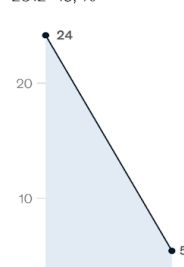


Figure 8: Moore's law contributing to diminishing returns on U.S. tech manufacturing

AI and the Future of Innovation and Economic Growth In the U.S.

Innovation has certainly been prevalent over the past 2 decades in America with introductions of internet accessing smart phones, GPS capabilities, 3D printing, etc. It seems that at this current moment in time we are on the brink of something potentially more revolutionary than all of these things: artificial intelligence. Since the release of Chat GPT and several other AI platforms in 2022, this new form of technology has amazed our society, and progressed extremely fast since. AI companies have done extremely well in the stock market over the past year such as NVIDIA due to all of the positive exposure AI has received. It truly takes the capabilities of the internet to the next level, leveraging a programmed mind which can be programmed to find any information available on the internet, and can teach itself to be better along the way. All in all it is understandable why many would assume that AI could be the thing to boost U.S. economic growth again, because of how much it can boost productivity and remove the need for human capital expenses. Unfortunately, this probably will not be the case for a long time. This is because the long and uncertain process of implementation by U.S. companies. According to Tera Allas, a director of research and economics at McKinsey, 60% to 70% of all work we are doing right now in America could already be automated using the technology available. For this reason, McKinsey analysts predict that AI could only end up averaging between a .1 to .6 percent increase in boosted productivity per year (Saint, 2024). Improved productivity is an essential ingredient in economic growth. By making current processes cheaper, quicker, and more efficient companies can generate higher revenues and profit margins. In fact in the past 3 decades, productivity has been the main driver of economic growth (Saint, 2024).

AI will impact different industries at different levels, and at different periods of time. McKinsey and Goldman Sacks analysts predict that the technology sector will benefit from AI first, by making better and faster microchips. It will then go on to impact office jobs with repetitive computer work such as programming. After this they predict it will impact restaurants and retail. McDonald's said that it will begin using AI to automate processes in December of 2024. Finally, they predict that AI will take a long time before it can positively impact manual labor jobs like construction and other sources of labor requiring physical work. These industries will be left behind by technology advancements because they do not leverage them in their operation (Saint, 2024).

This stagnation in implementation by industry, and overall delay in implementation are two main reasons why AI will not be able to make any major impacts on productivity or economic growth. Companies that are agile and already use a great deal of technology in their day to day will be the ones who are able to benefit the most from AI advancements. However, it will take quite some time for the entire country to experience growth from AI. The advantages of AI will require training, investment, and the ability to be flexible. This is not ideal for the United States, because the Federal Reserve has observed a recent slowing in economic growth, which is believed to continue into the future. A major indicator of the future of America's productivity and economic growth will be how quickly and competently American industries are able to implement AI as it grows and develops over the next decade.

Public Policy's Ability to Enhance U.S. Productivity:

In addition to AI, another significant factor which could dictate the direction of economic growth and productivity is public policy. Public policy is essentially the actions and decisions by governmental and economic bodies which encourage or discourage behavior. As mentioned earlier in this thesis, it was in large part Adam Smith who popularized the idea that governmental policies are a very important comment in spurring economic growth and increased productivity levels. It was his concept of laissez faire which became popular. This idea meant that by decreasing government intervention in the business ventures that its citizens are endeavoring, the freedom will lead to increased rates of competition, and thus innovation. One major action that the United States government could implant is preferential taxation to small businesses and startups. By doing this it not only encourages more innovation from these smaller and newer companies but rewards their success. Therefor there will be a greater incentive for them to compete and innovate in the market (Bryan, 2013). Another way in which the United States government and Federal Reserve can boost productivity in America is by increasing its transparency and decreasing the amount of uncertainty. Small businesses and startups which need to innovate in order to win the market are severely impacted and slowed down by public policy uncertainty. The government and Federal Reserve are difficult to predict, especially as of recent, and this makes it difficult for small and young companies to be aggressive and take risks. Taxes, government spending, and fiscal policy accounted for 40% of the policy related economic certainty since the 1980s (Bryan, 2013). Small and young startups do not know the best way to invest in themselves, or what direction to head in because the public economic policy in America has been constantly shifting. The government and Fed need to work to find a more stable and

helpful public policy if it wants to boost productivity levels by supporting startups and small companies.

Besides making reforms to laws and regulatory procedures, there are several other strategies our government could employ to boost the productivity levels in the United States. Investment is a fundamental instrument that can boost this nation's productivity levels and strength of the workforce. There are two major areas where these investments should be aimed: the research and development on innovative technology such as AI, and the skills of human capital through education. By having government directed research projects, there will be an increase in productivity and attainable value from tools such as AI. This is significant because as this thesis previously mentions, AI is projected to not make a major impact on the United States' productivity levels for a long time. Government investment into AI, and other innovative products and knowledge would greatly increase the amount of innovative products and ideas in our market and reduce the time it takes for them to be integrated and for the economy to benefit from them. Another reason government investment in research and development is because public investment is significantly more impactful than private investment in this case (Brynjolfsson, 2024). Private investment in research will mostly focus on smaller improvements that a company can use to get an advantage in the market which will help them in the short-term, however government investment will aim to make larger improvements and boost overall productivity in an industry. It has more money to leverage and more freedom to explore available options.

Another key area for government investment that can boost productivity levels in America is in human capital; the people themselves rather than the products they use. The best way to attain a larger, smarter, and more skilled workforce is twofold. The first method is to invest more in the education system. By investing in grade school education, there will be more accountability for teachers to do well in their jobs, more resources for students who need help specifically in math and science, potentially longer school days, and an overall improved experience. The goal with this investment is to boost how many students go on to study STEM related subjects; a field which produces a great deal of innovation and increased knowledge. There should also be a government investment in higher education to improve the quality of universities, and to increase the number of universities so that a higher number of skilled workers graduates each year (Hanauer, 2023). The second way that public policy can invest in human capital is by attracting skilled immigrants to come work in the United States. This is also one of the cheapest and easiest ways to increase the current human capital output in America. The advantage of this is that many of these immigrants will come to America already having the skills which would require years of education and training. By boosting the attractiveness of America as a destination for skilled immigrants, we would see a rapid increase in the strength, size, and intelligence of our workforce (Hanauer, 2023).

Conclusion

This thesis has provided a holistic view of what innovation and knowledge represent in an economic sense, by exploring the works of many paramount economists from David Warsh's book Knowledge and the Wealth of Nations. This book demonstrated how economists such as Adam Smith, Paul Romer, and Charles Kindleberger built off of each other's ideas to fully frame what innovation and knowledge really meant to a nation's economic growth, and ways which we could measure them. The thesis then explores the vital ingredient that is productivity, and how productivity improvements lead to economic growth. The Solow growth model furthered the stance of this thesis by tying together innovation with the variables it works with (human capital and capital accumulation) to affect economic growth. With a decreasing population, America has less human capital to allocate towards research and development projects which drive innovation and knowledge growth. The United States also is witnessing an increasing income inequality, which has created a lower class that has inferior access to educational tools and institutions. This results in providing the United States with a less skilled workforce to make up our human capital variable. This decreased access to a skilled workforce hurts our research and development process because less people have the education and skills to create new ideas and processes. The thesis then explains how cycles of production have passed their peaks and have now brought many industries to the point of diminishing returns on their productivity. This was proven especially true in the areas of manufacturing and the production of electronics.

Now that several of the main agents working against innovation have been identified, the question becomes how the United States can address them. Not every one of these obstacles can

be addressed as they are naturally occurring, however some of them can be. An obstacle such as uneven access to quality education greatly reduces how much innovation is able to help our economy. This is an issue which can be addressed and corrected. If we can continue to constantly grow the rate of college graduates there will eventually be greater social mobility, and a more skilled workforce which is able to fully utilize the fruits of innovation and knowledge advancements. This is an example of how public policy can have tremendous benefits if carried out correctly. Government increased investment in education and attracting a skilled immigrant workforce will get the United States a larger and more skilled workforce. Public policy can also increase the levels of productivity we are experiencing by providing tax incentives for small and young companies. These companies can create a lot of new innovation and knowledge through their mission to win in their markets.

As of right now the future does not look overwhelmingly bright for United States economic growth rates and productivity levels compared to the historic trends, despite the positive outlook society has about AI. Slow and uneven implementation of AI technology throughout the American economy will make it difficult for our economy to feel the full impact of what AI could be providing. This is where public policy could once again come into play. A big goal of public policy is to boost the skill level of our workforce. As this thesis has explained by the government investing in education it will naturally create a more skilled workforce. AI education could be an area that public policy invests heavily in, because it would allow it to be integrated more quickly into our workforce. If AI is integrated quicker, than naturally our productivity levels will increase because AI allows for widespread automation, an overall improved efficiency within the structure of companies. The United States is not currently in a

great position to leverage AI, which is harmful because it is only going to grow smarter and more applicable in the near future. Countries that have agile workforces and already leverage a lot of technology in their day-to-day operations will be the best equipped to leverage AI in the coming years. This is an area where I believe that public policy could have a major positive impact on our productivity levels over the coming decade.

The United States has established itself as one of the world's highest contributors and beneficiaries of innovation, and therefore the slowing economic growth it is experiencing is unnecessary. Hopefully identifying several of the key contributors to this gap is able to pave the way for solutions to arise. America has benefited from several waves of increased productivity, however no wave can be eternal. There need to be new approaches to building the economic growth rate back up in ways which utilize the evident tool which is innovation. Innovation and knowledge are going to continue to bring society better technology and improved processes. America needs to position itself in a way to realize the full potential of what it can be by leveraging these coming improvements. The gap between innovation and knowledge and the United State economic growth rate is telling a story. It essentially says that something is wrong with the structure of our economy, and the way our economic models are tracking growth. In a world where other global superpowers are rapidly improving their own economic positions, the united States government must stay on the cutting edge of this economic problem. The solutions are out there, and this thesis draws attention to the specific areas which should be addressed first.

Appendix

No interviews nor raw data was collected in the creation of this thesis. The sources used to build points are all correctly cited below in the bibliography.

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